**3GPP TSG-RAN WG1 Meeting #106-e R1-2108248**

**e-Meeting, August 16th – 27th, 2021**

**Agenda Item: 8.5.4**

**Source: Moderator (Huawei)**

**Title: FL summary #1 of 8.5.4 latency improvements for DL and DL+UL methods**

**Document for: Discussion and decision**

# Introduction

In RAN1#106-e, the following papers provided input on latency improvements for DL and DL+UL methods.

1. R1-2106452 Positioning latency enhancements Huawei, HiSilicon
2. R1-2106552 Discussion on latency reduction for NR positioning ZTE
3. R1-2106598 Discussion on latency enhancement for NR positioning vivo
4. R1-2106812 Considerations on latency improvements for positioning Sony
5. R1-2106891 Discussion on latency improvements for both DL and DL+UL positioning methods Samsung
6. R1-2106974 Discussion on latency reduction for NR positioning CATT
7. R1-2107060 Views on PHY Latency Reductions Nokia, Nokia Shanghai Bell
8. R1-2107134 Discussion on latency improvements for positioning methods China Telecom
9. R1-2107216 Enhancements on Latency Reduction in NR Positioning OPPO
10. R1-2107348 Enhancements for Latency Improvements for Positioning Qualcomm Incorporated
11. R1-2107406 Discussion on latency improvement for positioning CMCC
12. R1-2107545 Discussion on latency improvements for NR positioning LG Electronics
13. R1-2107593 Latency Reduction Solutions for NR Positioning Intel Corporation
14. R1-2107647 Discussion on latency improvements for DL and DL+UL positioning methods InterDigital, Inc.
15. R1-2107743 Views on Rel-17 positioning latency reduction Apple
16. R1-2107828 Aspects of physical latency improvement MediaTek Inc.
17. R1-2107861 Discussion on latency improvements for both DL and DL+UL positioning methods NTT DOCOMO, INC.
18. R1-2107923 Latency improvements for both DL and DL+UL positioning method Xiaomi
19. R1-2108144 Positioning Latency Reduction Enhancements Lenovo, Motorola Mobility
20. R1-2108167 Latency improvements for both DL and DL+UL positioning methods Ericsson

This paper provides the summary of solutions to improve positioning latency for DL and DL+UL methods.

[106-e-NR-ePos-04] Email discussion/approval on latency improvements for both DL and DL+UL positioning methods with checkpoints for agreements on August 19, 24 and 27 – Su (Huawei)

# M-sample PRS processing

## General information

Agreements made in RAN1#105-e.

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| Agreement:  M-sample (1<=M<4) PRS processing corresponding to measurements performed within M instances of the DL PRS resource set on a PRS resource, subject to UE capability, is beneficial from a RAN1 perspective for latency reduction.   * One sample corresponds to one instance * Send an LS to RAN4 informing that   + M-sample (1<=M<4) measurements corresponding to measurements performed within M (1<=M<4) instances of the DL PRS resource set on a PRS resource are beneficial for reduction of measurement latency from RAN1 point of view.   + RAN4 is requested to check the feasibility of measurements performed within M (1<=M<4) instances of the DL PRS resource set and identify the impact on requirements/side condition. * RAN1 to further study at least the following aspects for allowing M-sample (1<=M<4) PRS processing   + Details of UE capability   + Signaling details, e.g., to indicate whether measurement is based on one or more samples   + Whether the PRS sample processing time is defined and the relation with (N, T).     - Note: This may have RAN4 dependency |

The following sources mentioned their views on M-sample PRS processing.

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| **Company** | **Proposals** |
| Huawei [1] | **Proposal 1:** The existing NR-DL-PRS-ProcessingCapability and NR-DL-PRS-ResourceCapability should be also applied to M-sample PRS measurement.  **Proposal 2:**  Support LMF to explicitly request either M-sample or both M-sample and 4-sample PRS measurement, and if both are requested, UE include the M-sample in the early fix report and 4-sample in the normal location fix. |
| Samsung [5] | **Proposal 3:**FFS on how to determine the number of samples to be used for RSTD, UE Rx-Tx time difference and PRS-RSRP measurement: by LMF indication and/or UE implementation. |
| Nokia [7] | **Proposal 10**: RAN1 to discuss and gain common understanding on if PRS repetitions correspond to one sample or multiple samples. RAN4 involvement may also be necessary.  **Proposal 11**: Wait for RAN4 input before further agreements on M-sample PRS processing. |
| China Telecom [8] | **Proposal 1:** Rel-17 should support to report an extra signal indicating the sample number of PRS measurement to LMF. |
| Qualcomm [10] | **Proposal 3:** Support only M=1 for low-latency enhancements and de-prioritize specification support for M=2 and M=3.   * Introduce a UE capability whether a UE supports single-sample PRS processing   **Proposal 4:** Introduce signaling from the LMF in the Location Request message which signals to the UE that single-sample measurements are expected to be performed.   * FFS: Signaling details   **Proposal 5:** A UE should be able to report separate PRS processing capabilities for the case the UE performs single-sample (M=1) PRS measurements.   * FFS: Signaling details   **Proposal 7:** For single-sample processing, the measurement period for measuring a single sample can be equal to T according to the reported (N,T) PRS processing capabilities under the following conditions:   * During a first window with duration of at least N msec, referred to as “Measurement Window”, up to N msec of PRS symbols are expected to be measured by the UE. * During a second window of at least T-N msec, which starts after the end of the Masurement Window, referred to as “Processing window”,   + a UE is expected to process the measured PRS symbols and be capable of reporting the measurements after the end of the processing window   + a UE is not expected to receive any other DL signals or perform any other DL procedures * Minimum length of the Processing window shall be [4] msec |
| LGE [12] | **Proposal 1:**   * For request location information, introduce a parameter for distinguishing between a specific case (e.g. 1<=M<4 sample(s)) and the normal case (e.g. 4 samples) which is accompanied in request location information. The parameter can be included in the following IEs:   + Common IEs for request location information (e.g. CommonIEsRequestLocationInformation)   + Positioning method specific IEs (e.g. NR-DL-TDOA-ProvideLocationInformation, NR-DL-AoD-ProvideLocationInformation, NR-Multi-RTT-ProvideLocationInformation, etc.) |
| Intel [13] | **Proposal 2:**   * Support configurability of parameter M for UE DL PRS processing   + Further analyze signaling details to support configurability of parameter M |
| Lenovo [19] | **Proposal 3:** Support a new UE capability for at least N=1 sample measurement. |
| Ericsson [20] | **Proposal 3** Support measurement reports for RSRP and RSTD based on a single PRS measurement, i.e. Nsample= 1. |

**Signalling of number of samples**

* Supported by: Huawei [1], Samsung [5], China Telecom [8], Qualcomm [10], LGE [12], Intel [13]

**M=1**

* Supported by: Qualcomm [10], Lenovo [19], Ericsson [20]

**On the UE processing capability for M-samples**

* Huawei [1] think that the UE PRS processing capabilities should be reused
* Qualcomm [10] think that a separate PRS processing capabilities should be defined.

In addition

* Huawei [1] proposed to allow both M-sample and 4-sample measurement being requested at the same time, and in case of such a request, M-sample is reported via early fix report.
* Nokia [7] request to have a common understanding on the relation between samples and PRS repetitions.
* Nokia [7] also suggest to wait for RAN4 input before making any progress in RAN1.
* Qualcomm [10] propose to define measurement window and processing window inside the MG duration for 1-sample PRS processing.

## Round 1

Based on the input, the FL has the following initial tentative proposals.

### Proposal 2.1-1

* Support LMF to explicitly request UE to report the measurement with either M-sample or 4-sample.
* FFS signalling details, e.g. common IE or positioning method specific IE.

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| **Company** | **Yes/No** | **Comments** |
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### Proposal 2.1-2

* Support 1-sample (M=1) for PRS measurement subject to UE capabilities.
* FFS other sample numbers.

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| **Company** | **Yes/No** | **Comments** |
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### Proposal 2.1-3

* Further study the following aspects
  + Whether a new UE PRS processing capability is defined for M-sample PRS.
  + The relationship between measurement sample and PRS repetition, e.g. whether one measurement sample corresponds to processing a single repetition within multiple repetitions of a PRS transmission occasion.
  + If 1-sample PRS measurement is supported, whether a MG length can be split into PRS measurement window and PRS processing window.
  + Whether both M-sample and 4-sample PRS measurement report can be requested at the same time.

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| **Company** | **Yes/No** | **Comments** |
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## Round 2

# PRS measurement within MG

## General information

Agreements made in RAN1#105-e.

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| Agreement:  RAN1 to further study at least the following aspects for MG enhancement with regards to MG requesting and configuration/activation/triggering for the purpose of latency reduction for positioning:   * Preconfiguration of multiple MGs * Triggering/activation of MG(s) with lower layer signalings (DCI or DL MAC CE) * Request of MG(s) with lower layer signaling by the UE to the gNB * Request/determination of MG(s) by LMF indication to the gNB/UE * Note: The combination of the above items is possible. |

The following sources mentioned enhancements on PRS measurement within a MG.

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| **Company** | **Proposals** |
| Huawei [1] | **Proposal 9:** For the MG request, only support LMF based request.  **Proposal 10:** Support activation and deactivation of MG(s) from the preconfigured MGs via a MAC CE. |
| ZTE [2] | **Proposal 5:** For the sake of latency reduction related to the measurement gap, Rel-17 should allow LMF to request measurement gap.  **Proposal 6:** Enhance the measurement gap sharing scheme to prioritize the NR PRS measurement inside a measurement gap. RAN1 should send an LS to RAN4 on the benefits identified by RAN1. |
| vivo [3] | **Proposal 9:**   * + Pre-configured MG for positioning should be supported for NR positioning.     - Send an LS to RAN4 for informing this information   **Proposal 10:**   * + The common parameter of pre-configured MG for positioning is configured and transmitted to LMF/UE in advance, based on the Frequency layer information included in the MG request from LMF/UE, such as:     - Frequency domain information: PointA, StartPRB, Bandwidth and SubcarrierSpacing of frequency layer;     - Time domain information: gap offset, gap length and gap periodicity for the Frequency layer.   + FFS: Include MG type in MG request, MG type: regular MG, pre-configured MG   **Proposal 11:**   * + Further study the specific parameter of pre-configured MG for positioning, such as:     - Initial status of pre-configured MG: activated, deactivated.     - Whether the MG or activated status of MG is associated with the serving cell index and/or BWP index.   **Proposal 12:**   * + Pre-configuration MG activation/deactivation for positioning needs to be considered in Rel-17.   **Proposal 13:**   * + To consider the following options for pre-configured MG activation/deactivation     - Option1: LMF transmits a pre-configured MG activation/deactivation request to gNB by NRPPa information, and then gNB activates/deactivates pre-configured MG by lower layer signaling to UE;     - Option 2: LMF transmits a pre-configured MG activation/deactivation request to gNB by NRPPa information, and LMF activates/deactivates activate/deactivate pre-configured MG by LPP to UE;     - Option 3: UE expects the MG is activated when PRS measurement within pre-configured MG is needed, e.g. when active DL BWP doesn’t satisfy the PRS measurement (bandwidth and/or SCS), and/or LPP Request Location Information is applied;       * FFS: Autonomously/implicitly triggering via event at gNB and UE, e.g. triggerred by reception of LPP Request Location Information, triggered by relationship between active BWP and PRS     - Option 4: UE requests the MG activation to gNB when PRS measurement within pre-configured MG is needed, e.g. when active DL BWP doesn’t satisfy the PRS measurement (bandwidth and/or SCS), and/or LPP Request Location Information is applied. And then gNB activates/deactivates pre-configured MG by lower layer signaling to UE.   **Proposal 14:**   * + Pre-configuration and/or activation/deactivation of an MG associated with on-demand PRS needs to be considered in Rel-17.   **Proposal 16:**   * + Priority rules should be supported for the processing/reception of DL PRS and other signals/channels or sharing MG.   **Proposal 17:**   * + Priority rules for positioning measurement and report should be supported in Rel-17 positioning. |
| SONY [4] | **Proposal 1:** gNB provides the supported MG configuration(s) to UE / LMF.  **Proposal 2:** Support triggering/activation of MG(s) with layer-1 signalling (e.g., via DCI).  **Proposal 3:** Measurement gap request/indication for low latency positioning measurement purpose can be provided to gNB either from LMF (via NRPPa) or UE (via UCI). |
| CATT [6] | **Proposal 7:** To reduce latency, the aperiodic measurement gap for NR positioning should be introduced in Rel-17.  **Proposal 8:** For on-demand DL PRS, support the following methods related to the measurement gap configuration for reducing the positioning latency:   1. Either a UE or serving gNB may inform LMF about the existing measurement gap configuration for the UE. 2. LMF may determine and send the recommended transmission time of on-demand DL PRS for a UE to the gNBs based on the UE’s capability of whether to support positioning measurement without a measurement gap. 3. LMF informs UE of the expected measurement gap before on-demand PRS is configured to UE by LMF.   **Proposal 9:** Support LMF to send the recommended measurement gap configuration for a UE to the serving gNB for reducing the positioning latency. |
| Nokia [7] | **Proposal 2**: Determination of MG(s) by LMF is not supported.  **Proposal 3**: Request of MG(s) by the LMF to the UE is not supported.  **Proposal 4**: RAN1 to focus the study of the prior agreement to requesting MG(s) with lower layer signaling by the UE to the gNB. |
| China Telecom [8] | **Proposal 2:** Rel-17 should support a periodical PRS measurement with MG for reducing the latency caused by RRC signal. |
| OPPO [9] | **Proposal 5:** Support using lower-layer signaling (DCI-based or MAC CE-based) to trigger or activate measurement gap configuration.  **Proposal 6:** Support lower-layer signaling based (PUCCH-based or MAC-CE based) measurement gap request.  **Proposal 7:** One triggered measurement gap can happen multiple repetitions and then stop. |
| Qualcomm [10] | **Proposal 1:** For Measurement gaps shared between Positioning and mobility measurements, support increased priority of processing of Positioning resources when low-latency Positioning Measurements are expected by the UE.  **Proposal 2:** Support configuring a separate Measurement Gap for the purpose of Positioning only.  **Proposal 8:** For low latency MG request, support request of MG(s) with an UL MAC-CE from the UE.  **Proposal 9:** For low latency MG configuration, support configuration and/or activation of MG(s) with DL MAC-CE from the UE.   * FFS: Whether multiple MGs are needed to be previously configured and relation to the MAC-CE signaling.   **Proposal 10:** For low latency Positioning, consider the option of autonomous MG for Positioning, wherein the UE, after it receives a low-latency location request, it is allowed to drop other DL signal processing/traffic during one or more window(s) of time without an explicit request/configuration from the serving gNB.   * Note: Coordination between UE-serving gNB-LMF may be specified to ensure seamless operation of the autonomous MG for Positioning. * FFS: Signaling details between the LMF and the serving gNB * FFS: UE capabilities, duration of time of the autonomous gaps   **Proposal 11:** In NR Rel-17, for low latency positioning, support only a MG-based PRS processing (The option of autonomous MG-based Processing is not precluded, and we consider it as an enhancement of the legacy MG-based PRS processing feature). |
| CMCC [11] | **Proposal 4:** With regards to MG requesting and configuration/activation/triggering for the purpose of latency reduction for positioning, at least support:   * Pre-configuration of multiple MGs, details can be up to RAN4; * Semi-persistent, aperiodic, on-demand MGs, details can be up to RAN4; * Triggering/activation of MG(s) with lower layer signalings (DCI or DL MAC-CE) * Request of MG(s) with lower layer signaling by the UE to the gNB (UCI or UL MAC-CE) |
| LGE [12] | **Proposal 3:**   * If CG-based PUSCH is applied for positioning measurement report, ‘the lower layer signaling for triggering/activation of measurement gap(s) (MG(s)) (which is discussed as a method for MG enhancement in the previous meeting [2]) can be reused for activation of CG-based PUSCH resources for positioning measurement reporting.   **Proposal 4:**   * The information for indicating which CG-based PUSCH is used for is necessary to be included in lower layer signaling for triggering/activation of MG(s) when CG-based PUSCH is supported for the MG without case. |
| Intel [13] | **Proposal 1:**   * To reduce latency of NR positioning with MGs for DL PRS processing define the following enhancements   + Support pre-configuration of multiple MG patterns for DL PRS processing by UE   + Support DCI signaling to activate pre-configured MG for DL PRS processing by UE   + Optimize Rel.16 measurement gap patterns (e.g., period, length) for NR DL PRS processing by UE     - Send LS to RAN4 with a recommendation to optimize MG patterns for positioning   + Consider physical layer signaling (e.g., SR) for MG request, if DCI based MG activation is agreed * Send LS to RAN2/RAN4 capturing outcome of the RAN1 discussion on MG enhancements for NR positioning latency reduction and ask for feedback |
| IDC [14] | **Proposal 4:** Support fast activation of preconfigured measurement gap via MAC-CE  **Proposal 5 :** Preconfigured measurement gap patterns are characterized by repetition period, length and offset  **Proposal 6:** Support priority indication for the measurement gap associated with PRS. |
| Apple [15] | **Proposal 5**: NW provides assistance data to UE based on which UE is configured with one or more MG configurations and A-PRSs associated with each MG.   * A MG and PRS resources associated with that MG may be triggered/activated by UE specific DCI, or GC-DCI or MAC-CE signaling |
| MTK [16] | **Proposal 2-1**: RAN1 may reach agreement that the main bottleneck is that UE needs to indicate the location measurement to the gNB when UE senses that the MG is not sufficient for DL-PRS measurement. This is because the gNB doesn't know which UE of camping on is going to perform DL-PRS measurement  **Proposal 2-2**: When the agreement is reached, send LS to RAN2/RAN3 for the signalling between LMF and gNB for the notification of which UE under location request |
| Xiaomi [18] | **Proposal 4:** Support triggering of on-demand measurement gap by MAC CE or DCI.  **Proposal 5:** Suggest to associate a state ID with a PRS configuration, a measurement gap configuration and a PRS measurement report configuration, and MAC CE or DCI can activate/deactivate or trigger the PRS measurement report by indicating a state ID.  **Proposal 7:** Consider of simultaneous reception of PRS and data by different panel for MPUE by panel specific measurement gap. |
| Lenovo [19] | **Proposal 2:** RAN1 to consider the latency reduction benefits of lower MGRPs. Send LS to RAN4 to determine feasibility of such an MG enhancement. |

**FL comments:**

It is the FL understanding that the MG activation request/MG activation may not necessarily reply on preconfiguration, which motivates decoupling of the following three aspects.

**Preconfiguration of multiple MGs**

* Supported by vivo [3], SONY [4], CMCC [11], Intel [13], IDC [14], Xiaomi [18]

**MG activation request**

* By LMF
  + Supported by Huawei [1], ZTE[2], vivo [3], SONY [4], MTK [16]
* By UE, e.g. UL MAC CE, UCI
  + Supported by vivo [3], SONY [4], CATT? [6], Nokia [7], OPPO [9], Qualcomm [10], CMCC [11], Intel [13]
* In addition
  + Nokia [4] do not support request of MG by the LMF to the UE.
  + MTK [16] claim that the bottleneck is that the gNB doesn't know which UE camping on it is going to perform DL-PRS measurement.

**MG activation by**

* DL MAC CE
  + Supported by: Huawei [1], OPPO [9], Qualcomm [10], CMCC [11], IDC [14], Xiaomi [18]
* DCI
  + Supported by: SONY [4], CATT? [6], OPPO [9], CMCC [11], Intel [13], Apple [15], Xiaomi [18]
* Lower layer signalling
  + Supported by: vivo [3], Nokia [7], OPPO [9], CMCC [11], LGE [12]
* LMF
  + Supported by: vivo [3], CATT [6]
  + Not supported by: Nokia [4]

**On autonomous gap activation**

* vivo [3] support autonomous/implicit triggering under some event
* Qualcomm [10] support autonomous MG similar to system information acquisition of a neighbouring cell in LTE or ANR in NR.

**For measurement gap sharing**

* ZTE [2] proposed to enhance the gap sharing mechanism to prioritize PRS measurement within the MG
* vivo [3] proposed to define priority rules for PRS in case of MG sharing.
* Qualcomm [10] proposed to support increased priority of positioning resources in the MG when lower latency positioning measurements are expected, and in addition also support positioning only MG.
* IDC [14] proposed to support priority indication for the PRS associated MG.

**For MG pattern enhancements**

* Intel [13] proposed to support optimization of Rel-16 MG patterns (e.g. period, length).
* Lenovo [19] proposed to lower MGRPs.

In addition

* vivo [3] proposed MG activation associated with on-demand PRS.
* CATT [6] proposed UE or gNB reporting to LMF on the existing MG
* China Telecom [8] proposed to support periodical PRS measurement with MG.
* OPPO [9] proposed triggering MG can repeat multiple times and then stop.
* Xiaomi [18] proposed associating PRS configuration, MG configuration, and measurement report configuration with a state ID, and activation/deactivation or triggering can be based on the ID.
* Xiaomi [18] also proposed panel-specific MG.

## Round 1

Based on the input, the FL has the following initial tentative proposals.

### Proposal 3.1-1

* For the purpose of positioning latency reduction, support pre-configuration of multiple MGs by the gNB.

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| **Company** | **Yes/No** | **Comments** |
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### Proposal 3.1-2

* For the purpose of positioning latency reduction, support a new mechanism of MG request.
  + Further study the following options.
    - Option. 1: by LMF (via a NRPPa message)
    - Option. 2: by UE (via UCI or UL MAC CE)

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| **Company** | **Yes/No** | **Comments** |
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### Proposal 3.1-3

* For the purpose of positioning latency reduction, support a new mechanism of MG activation and deactivation.
  + Further study the following options.
    - Option. 1: DCI
    - Option. 2: DL MAC CE
    - Option. 3: UE autonomously applies the MG
  + FFS whether deactivation can be implicit via configurable number of the MG occasions

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| **Company** | **Yes/No** | **Comments** |
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### Proposal 3.1-4

* Further study mechanisms to prioritize positioning measurement inside the MG
  + Option 1: Positioning measurement is prioritized over other RRM
  + Option 2: Define positioning-only MG
  + Other options are not precluded.

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| **Company** | **Yes/No** | **Comments** |
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### Proposal 3.1-5

* Further study the following aspects
  + MG pattern enhancements, e.g. lower MGRP, other MGL
  + Reporting of existing MG to the LMF
  + Joint configuration/activation of MG, (on-demand) PRS, and/or location measurement
  + UE panel specific MG

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| **Company** | **Yes/No** | **Comments** |
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## Round 2

# PRS measurement without MG

## General information

Agreements made in RAN1#105-e.

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| Agreement:   * Further study the following options (with the same numerology) to support PRS measurement without MGs for latency reduction in Rel-17   + Option 1: The PRS is from the serving cell and UE measurement is inside the active DL BWP   + Option 2: The PRS can be from the serving cell and non-serving cell, and UE measurement is inside the active DL BWP   + Option 3: The PRS (from the serving cell or non-serving cell) used for UE measurement may extend outside or be completely outside the active DL BWP (including with potentially a different numerology)   + Note: RAN1 strives not to increase the PRS measurement time compared with Rel-16 MG-based measurement * The following aspects are FFS   + PRS processing prioritization window   + Mechanism to trigger UE DL PRS measurements and report   + UE/gNB assumptions on processing of DL PRS and other DL physical channels / signals   + UE DL PRS processing capabilities * Note: Companies are encouraged to compare the latency benefits of introducing MG-less PRS measurements over MG-based PRS measurements * Note: Depending on the comparison of latency benefits (and other considerations such as complexity) between introducing MG-less PRS measurements and MG-based PRS measurements, none/one/multiple of the above options should be adopted in Rel-17. |

The following sources mentioned enhancements on PRS measurement without a MG.

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| **Company** | **Proposals** |
| Huawei [1] | **Proposal 4:** Support Option 2 with the modification for PRS measurement without MG.   * Option 2: The PRS can be from the serving cell and non-serving cell, and UE measurement is inside the active DL BWP   + Note: The timing of the serving cell and the non-serving cell should be aligned.   + Note: The PRS configuration bandwidth may extend outside the active DL BWP.   **Proposal 5:** Support PMTC for PRS measurement without MG, where UE is only required to measure the PRS inside the PMTC.   * FFS explicit configuration by LMF or gNB or implicit derivation by the UE   **Proposal 6:** Support communication in the PMTC at least for the case when the communication symbols is not overlapped with PRS symbols.   * Note: This applied for the case when PRS symbol timing from the non-serving cell is aligned with that from the serving cell. * FFS: Scheduling availability on additional symbols preceding and succeeding the PRS symbols.   **Proposal 7:** Support under UE capability the simultaneous processing of PRS only from the serving cell and data in FR1.  **Proposal 8:** Support scheduling restriction on PRS symbols in the PMTC if the PRS to measure concerns any non-serving cell or any cell in FR2 or if UE does not support simultaneous processing of PRS only from the serving cell and data in FR1. |
| vivo [3] | **Proposal 2:**   * + PRS measurement without MG and PRS measurement with MG enhancement can be supported together in Rel-17 for maximizing the advantages of the two methods.   **Proposal 3:**   * + PRS measurement without MGwhen PRS is within active DL BWP should be specified.   **Proposal 4:**   * + To support the case (case 2) of option 1 and option 2 where PRS partially within active BWP, consider enhancing the reporting information, for example,     - UE capability reporting, including without MG capability.     - Active BWP information reporting.   **Proposal 5:**   * + To support the case (case 2) of option 1 and option 2 that UE PRS partially within active BWP, consider enhancing the UE measurement procedure or signaling, for example,     - if the overlapping bandwidth of active BWP and PRS can satisfy the performance requirement, UE measurement can be inside the active BWP. Otherwise, the UE can request MG(s) or BWP switching.   **Proposal 6:**   * + Support option 1 and option 2 for latency and complexity reduction.     - Option 1: The PRS is from the serving cell and UE measurement is inside the active DL BWP     - Option 2: The PRS can be from the serving cell and non-serving cell, and UE measurement is inside the active DL BWP   **Proposal 7:**   * + Further study the signaling and procedure for supporting option 3 as an alternative to using MG.     - Option 3: The PRS (from the serving cell or non-serving cell) used for UE measurement may extend outside or be completely outside the active DL BWP (including with potentially a different numerology)   **Proposal 8:**   * + Supporting PRS measurement or processing prioritization window for centralized on-demand PRS     - centralized on-demand PRS: on-demand PRS is configured/requested within the PRS measurement or processing prioritization window   **Proposal 16:**   * + Priority rules should be supported for the processing/reception of DL PRS and other signals/channels or sharing MG. |
| SONY [4] | **Proposal 4:** Positioning measurement without measurement gap is supported and subject to certain conditions to enable such operation.  **Proposal 5:** UE intend to perform positioning without measurement grant can indicate to the serving gNB and serving gNB can provide the response whether the UE is allowed to perform positioning measurement (e.g., when it is needed) within certain duration of time. |
| Samsung [5] |  |
| CATT [6] | **Proposal 5:** At least Option 3 should be supported in Rel-17. Option 1 and option 2 can also be supported for UEs with different capabilities.  **Proposal 6:** When a UE has the capability to support PRS measurement without MGs, the UE is expected to perform DL PRS measurement and reporting simultaneously with other DL channels transmission/reception without the interruption of the DL data communication. Thus, there is no need to define PRS processing prioritization window, and the gNB assumes on the processing of DL PRS and other DL physical channels/signals.  **Proposal 6:** When a UE has the capability to support PRS measurement without MGs, the UE is expected to perform DL PRS measurement and reporting simultaneously with other DL channels transmission/reception without the interruption of the DL data communication. Thus, there is no need to define PRS processing prioritization window, and the gNB assumes on the processing of DL PRS and other DL physical channels/signals. |
| Nokia [7] | **Proposal 5**: Support option 2 from the prior agreement: the PRS can be received from the serving cell and non-serving cell, and UE measurement is inside the active DL BWP. |
| China Telecom [8] | **Proposal 3:** Rel-17 should support the DL PRS frequency domain multiplexed with other DL signals and channels in PRB-level. |
| OPPO [9] | **Proposal 1:** Support measuring DL PRS resource without measurement gap when DL PRS resource is within the active DL BWP and with the same numerology of the active DL BWP and from the serving cell.   * This is subject to UE capability.   **Proposal 2:** Define new DL PRS processing capability for the case when measurement gap is not configured.  **Proposal 3:** On the symbols where the UE measures DL PRS resource, the UE is not expected to receive DL channel or reference signal.  **Proposal 4:** The DL PRS resource and SSB can be mapped onto the same symbol and the UE is indicated with if the UE shall receive DL PRS resource or SSB. |
| Qualcomm [10] | **Proposal 11:** In NR Rel-17, for low latency positioning, support only a MG-based PRS processing (The option of autonomous MG-based Processing is not precluded, and we consider it as an enhancement of the legacy MG-based PRS processing feature). |
| CMCC [11] | **Proposal 1:** Support the UE to measure the DL PRS without measurement gap, when the PRS from the serving cell and non-serving cell is inside the active DL BWP and with the same numerology as the active DL BWP.  **Proposal 2:** Support the UE to process DL PRS and other DL signals/channels that are multiplexed in an FDM manner in the same OFDM symbol.  **Proposal 3:** Support introducing physical layer priority for DL PRS and DL signals/channels carrying LPP signaling. |
| IDC [14] | **Proposal 1:** Measurements and processing of PRS without measurement gap should be supported with at least Option 1 (The PRS is from the serving cell and UE measurement is inside the active DL BWP)  **Proposal 2:** In the presence of no measurement gap, the UE is expected to receive PRS with higher priority, associated with on-demand PRS, over other channels if the PRS overlaps with other channels in the time domain.  **Proposal 3:** Support priorities related to measurement reports and priority depends on types of PRS (e.g., on-demand PRS) that is associated with the report. |
| Apple [15] | **Proposal 1**: For PRS measurement without/outside MGs, support subject to UE capability, the PRS from the serving cell and non-serving cell can be received and measured within UE’s active DL BWP.  **Proposal 2**: support under UE capability an indication to switch to a BWP associated with positioning measurements, by   * Alt1: UE-specific DCI * Alt2: GC-DCI * Alt3: In a periodic higher layer configured by LMF   **Proposal 3**: M-BWP configuration may include the time duration which M-BWP will last   * In this case, once the time is expired, UE would switch to a default BWP or back to the active BWP before switching to M-BWP * Alternatively, UE would stay in M-BWP until further indication to switch to another (regular) BWP is received   **Proposal 4**: For PRS measurement outside/without MG, e.g. once UE receives the indication to switch to Measurement BWP (M-BWP), UE is not expected to receive or transmit data within the M-BWP |
| DCM [17] | **Observation 1:**   * Regarding MG-less based positioning, priority rule between DL-PRS and other channels/signals should be specified   **Observation 2:**   * If priority rule between DL-PRS and other channels/signals is introduced, whether the margin period around DL-PRS symbols is necessary or not can be considered |
| Xiaomi [18] | **Proposal 6:** to discuss the UE behavior when PRS resource on symbols are indicated as UL or used by other DL signals or channels transmission with gap-less measurement for positioning.  **Proposal 8:** The priority of PRS should be differentiated for different latency requirement. |
| Ericsson [20] | **Proposal 1** In NR Rel-17, support DL measurements based on DL PRS without the UE having to request measurement gaps.  **Proposal 2** Introduce an indicator in the assistance data signaling that the PRSs present in the measurement request can be measured without measurement gaps.  **Proposal 5** For priority of the PRS against other downlink reference signals and channels, support the following   * + The PRS from a serving cell is subject to dropping rules/priority indications.   + The PRS transmitted from non-serving cell is expected to be measured in a measurement gap if the neighbour cell PRS symbols do not coincide with the serving cell PRS symbols.   + For PRS transmissions from TRPs in a serving cell, the PRS collisions with PDSCH/CSI-RS can be handled via priority indicators   + For PRS transmissions from TRPs in a serving cell, whether PRS is dropped or not depends on the priority indicator   **Proposal 6** In NR Rel-17, support reserved resources for PRS where PDSCH data are resource mapped around the reserved resources for PRS. |

**For MG-less PRS measurement conditions**

* Option 1: The PRS is from the serving cell and UE measurement is inside the active DL BWP
  + Supported by: vivo [3], CATT [6], OPPO [9], IDC [14]
* Option 2: The PRS can be from the serving cell and non-serving cell, and UE measurement is inside the active DL BWP
  + Supported by: Huawei [1], vivo [3], CATT [6], Nokia [7], CMCC [11], Apple [15]
  + Huawei [1] proposed that in this case, the timing of the serving and the non-serving cell should be aligned.
* Option 3: The PRS (from the serving cell or non-serving cell) used for UE measurement may extend outside or be completely outside the active DL BWP (including with potentially a different numerology)
  + Supported by: CATT [6]
  + vivo [3] proposed for further study.
* MG-less PRS measurement (without mentioning preference of Options)
  + Supported by: SONY [4], Ericsson [20]
  + Not supported: Qualcomm [10]

**For the UE PRS measurement capability without MG**

* vivo [3], OPPO [9] proposed to define a new UE PRS processing capability without MG.

**For the handling of frequency domain aspects of PRS measurement without MG**

* vivo [3] proposed that UE can measure the overlapping BW of PRS with the active DL BWP if the overlapping BW satisfies the performance requirement, and UE can request MG or BWP switching otherwise.
* Apple [15] proposed to introduce M-BWP, which can be switched via UE-specific DCI, GC-DCI, or in a periodic manner configured by LMF, and discussed potential ways of switching back to a “regular” BWP.

**For the handling of time domain aspects of PRS measurement without MG**

* Huawei [1] proposed to introduce PMTC, only inside which UE is required to measure the PRS.
* vivo [3] proposed to introduce PRS measurement/processing prioritization window for centralized on-demand PRS.
* CATT [6] proposed not to define PRS processing prioritization window.

**For priority rules**

* Huawei [1] proposed scheduling restrictions in PMTC, as well as simultaneous PRS and data processing in FR1 subject to UE capability.
* vivo [3] proposed a prioritized on-demand PRS processing in a window, and also proposed to define priority rules with other signals/channels.
* CATT [6] proposed that UE should be able to perform PRS measurement simultaneously with other DL channels/transmission/reception, if UE supports PRS measurement without MG.
* China Telecom [8] proposed to support DL PRS FDM with other DL signals and channels in PRB-level.
* OPPO [9] proposed to prioritized PRS over DL channel/reference signals on a symbol-level.
* CMCC [11] proposed to support processing DL PRS and other FDMed DL signals/channels, and also proposed to indicate physical layer priority for DL-PRS and DL signals/channels carrying LPP signaling (if simultaneous processing is not supported by the UE).
* IDC [14] proposed to higher priority for (on-demand) PRS over other channels overlapping in time domain.
* Apple [15] proposed no data transmission or reception in M-BWP.
* DCM [17] observed the need to define priority rule between PRS and other channel/signals, and consider the margin period around DL PRS symbols.
* Xiaomi [18] proposed to discuss UE behaviour on PRS symbol indicated as UL or used by other DL signals or channels, and also proposed differentiated PRS priority subject to different latency requirement.
* Ericsson [20] proposed to support priority rule/indicator for handling PRS from serving cell and PDSCH/CSI-RS reception, and we think that PRS from neighbouring cells that is not overlapped with PRS from the serving cell should always be measured in a MG.

In addition

* vivo [3] proposed to introduce UE active BWP information reporting (to LMF)
* SONY [4] proposed that UE can indicated to the serving gNB (on PRS measurement) and the serving gNB can indicate whether UE is allowed to perform PRS measurement without “measurement grant” within a certain duration of time.
* Ericsson [9] proposed to introduce the indicator in the AD whether the PRSs present in the measurement request can be measured without MGs.

## Round 1

Based on the input, the FL has the following initial tentative proposals.

### Proposal 4.1-1

* Support PRS measurement without MG at least for the case when PRS is from the serving cell and the UE measurement is inside the active DL BWP.
  + Note PRS should have the same numerology as the current DL BWP.
  + FFS conditions to apply to PRS from the non-serving cell (e.g. synchronization, time domain overlapping with the serving cell).
  + FFS whether and how UE may suggest BWP changes to the serving gNB to fit the PRS measurement if the MG-less measurement condition does not satisfy.
  + FFS whether a new UE PRS processing capability is defined.

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| **Company** | **Yes/No** | **Comments** |
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### Proposal 4.1-2

* At least support prioritized PRS measurement over other DL signals and channels within a PRS processing prioritization window for PRS measurement without MG.
  + FFS signalling details.
  + FFS whether UE can support simultaneous PRS and data processing subject to UE capability.
  + FFS whether the PRS is restricted to on-demand PRS.
  + FFS whether PRS and SSB can be mapped to the same symbol.

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| **Company** | **Yes/No** | **Comments** |
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### Proposal 4.1-3

* Further study assistance information transfer to enable/instruct UE to perform PRS measurement without MG, including but not limited to
  + UE active DL BWP report to LMF.
  + Measurement grant by the gNB.
  + Indication of MG-less PRSmeasurement from LMF.

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| **Company** | **Yes/No** | **Comments** |
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## Round 2

# UL grant for measurement report

## General information

The following sources mentioned enhancements on UL grant for measurement report.

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| **Company** | **Proposals** |
| Samsung [5] | **Proposal 1:** Configured grant PUSCH type 1 and type 2 is used for positioning measurement report in order to reduce the latency.  **Proposal 2:** The DG PUSCH with high priority is considered for positioning measurement report to reduce the latency. |
| CATT [6] | **Proposal 4:** To reduce the measurement latency, support LMF to inform serving gNB when the UE will report location measurement result, which allows the serving gNB sends the UL grant to UE before the measurement gap. The UL grant schedules the UL resource for the UE to send the measurement report in a proper time right after the measurement gap. |
| Nokia [7] | **Proposal 1:** UE could request the expected measurement report resource from the serving gNB via RRC signaling to minimize the positioning measurement report delay. |
| LGE [12] | **Proposal 2:**   * For latency reduction of positioning measurement reporting, preconfigured resource based measurement reporting (e.g., CG-based PUSCH) should be introduced.   **Proposal 3:**   * If CG-based PUSCH is applied for positioning measurement report, ‘the lower layer signaling for triggering/activation of measurement gap(s) (MG(s)) (which is discussed as a method for MG enhancement in the previous meeting [2]) can be reused for activation of CG-based PUSCH resources for positioning measurement reporting.   **Proposal 4:**   * The information for indicating which CG-based PUSCH is used for is necessary to be included in lower layer signaling for triggering/activation of MG(s) when CG-based PUSCH is supported for the MG without case. |
| Apple [15] | **Proposal 7**: At least for the case of M-BWP switching, NW configures (as part of M-BWP configuration and/or indication) PUSCH resource for UE to report positioning measurements and/or location information   * The grant is specifically configured for positioning measurement report, e.g. Nx symbols after the end of last symbol of last DL-PRS resource, or after the end of M-BWP * Nx is determined based on UE capability |
| Xiaomi [18] | **Proposal 3:** Support PRS measurement report by PUSCH including configured grant PUSCH and dynamic grant PUSCH. |

**For enhancement on assistance for the PUSCH resource to contain the measurement report**

* Samsung generally support CG and higher priority DG PUSCH to carry the positioning measurement report.
* CATT proposed to support LMF indication to the gNB on the measurement reporting time.
* Nokia proposed to support UE indication to the gNB on the measurement reporting resource (PUSCH) via RRC.
* LGE proposed to support CG-PUSCH for positioning measurement reporting, and propose to define joint request and activation of CG-PUSCH and MG with lower layer signaling.
* Apple proposed to support joint configuration/indication/grant of M-BWP and PUSCH resource.
* Xiaomi proposed to support CG-PUSCH and DG-PUSCH for measurement report.

## Round 1

Based on the input, and considering that this issue was discussed in RAN1#105-e, and some companies expressed concern, the FL has the following initial tentative proposal.

### Proposal 5.1-1

* Further study assistance information to the gNB for configuration/scheduling of the PUSCH that carries the positioning measurement report, where the assistance information includes at least the expected time of the positioning measurement report.
  + Note: the PUSCH may include dynamic grant (DG) based PUSCH and configured grant (CG) based PUSCH (type 1 and type 2)
  + FFS initiated from UE or LMF
  + FFS details of assistance information

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| **Company** | **Yes/No** | **Comments** |
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## Round 2

# Triggering PRS and measurement report in lower layers

## General information

The following sources mentioned lower layer triggered PRS (AP/SP PRS) and positioning measurement report.

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| **Company** | **Proposals** |
| vivo [3] | **Proposal 15:**   * + - The request of the measurement via MAC-CE and/or physical layer procedure should be supported. |
| CATT [6] | **Proposal 1:** AP PRS and SP-PRS receptions triggered by serving gNB should be supported for single gNB positioning, in which a UE is informed to measure the DL PRS of the TRPs of the same gNB.  **Proposal 2:** Reception of AP-PRS or SP-PRS triggered by LMF through LPP message should be supported.  **Proposal 3:** UE can be triggered to receive periodic PRS through the DCI or MAC CE to reduce the latency. |
| Apple [15] | **Proposal 5**: NW provides assistance data to UE based on which UE is configured with one or more MG configurations and A-PRSs associated with each MG.   * A MG and PRS resources associated with that MG may be triggered/activated by UE specific DCI, or GC-DCI or MAC-CE signaling   **Proposal 6**: In case of A-PRS, triggered by lower layer signaling, collides with a SP/P-PRS, SP/P-PRS is fully or partially (only overlapping symbols) cancelled. |
| Xiaomi [18] | **Proposal 1:** on-demand PRS should support periodical transmission, semi-persistent transmission and aperiodic transmission.  **Proposal 2:** gNB initiated of on-demand PRS transmission can be supported by RRC, MAC CE and DCI.  **Proposal 5:** Suggest to associate a state ID with a PRS configuration, a measurement gap configuration and a PRS measurement report configuration, and MAC CE or DCI can activate/deactivate or trigger the PRS measurement report by indicating a state ID. |

**On AP/SP PRS**

* Supported by: CATT [6], Apple [15], Xiaomi [18]

**On measurement reported triggered by lower layers**

* Supported by: vivo [3], CATT [6], Xiaomi [18]

## Round 1

Based on the input, the FL has the following initial tentative proposals.

### Proposal 6.1-1

* Study mechanisms to support AP-PRS and SP-PRS reception.
  + Note: including priority between periodic PRS and AP-PRS/SP-PRS.

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| **Company** | **Yes/No** | **Comments** |
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### Proposal 6.1-2

* Study mechanisms to support positioning measurement and measurement report triggered via lower layers.
  + Note: lower layer-based MG activation is a separate issue.

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| **Company** | **Yes/No** | **Comments** |
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## Round 2

# SRS priority

## General information

The following sources mentioned enhancements on SRS priority.

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| **Company** | **Proposals** |
| Nokia [7] | **Proposal 6**: RAN1 should study and work on new priority rules of transmitting SRS for positioning with other UL signals/channels, in order to reduce positioning latency for UL and DL+UL positioning methods. |
| CMCC [11] | **Proposal 5:** The SRS for positioning priority enhancements is within the WI scope, and should be further studied.  **Proposal 6:** Support introducing physical layer priority indication for SRS for positioning. |

## Round 1

Based on the input, the FL has the following initial tentative proposal.

### Proposal 7.1-1

* For the purpose of positioning latency reduction, at least support dropping of lower priority PUSCH that is overlapped with higher priority positioning SRS.
* FFS: How priority is indicated.

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| **Company** | **Yes/No** | **Comments** |
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## Round 2

# Multi-stage measurement report

## General information

The following sources mentioned enhancements on measurement report with multiple stages.

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| **Company** | **Proposals** |
| ZTE [2] | **Proposal 1:** In order to reduce UE measurement time of a location information report, LMF should be allowed to select a subset of DL PRS from DL PRS in ProvideAssistanceData message for UE to measure and report the location information report.  **Proposal 2:** In order to get quick response of an early location information report, LMF should be able to configure an early location information report associated DL PRS used to derive the early location information report.  **Proposal 3:** For the purpose of reporting new location measurements in time, Rel-17 should allow UE to report multiple early location information reports prior to a response time. |
| Lenovo [19] | **Proposal 1:** RAN1 to support explicit priority indications to increase flexibility of the UE of processing and providing different low latency measurement reports to the LMF, which is applicable to the following:   * Assistance Data (e.g., subset of PRS resources, TRP, beam info). * Measurement and Reporting Configurations (enable multiple low latency response times). |

## Round 1

Based on the input, the FL has the following initial tentative proposals.

### Proposal 8.1-1

* Further study procedures to enable positioning measurement reports in multiple stages, including
  + Multiple response times
  + Relationship with early location report.
  + Whether and how PRS resources for measurement and report are selected in each stage.

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| **Company** | **Yes/No** | **Comments** |
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## Round 2

# Additional UE PRS processing capability

## General information

The following sources mentioned additional UE PRS processing capability.

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| **Company** | **Proposals** |
| Huawei [1] | **Proposal 3:**  Support a new set of (N, T) with N being the slot duration or 1 msec value.   * The measurement period requirement if UE supports multiple sets of (N, T) (one for Rel-16, and one for Rel-17) is adapted to be the smaller one. * Send an LS to RAN4 to ask them to check the feasibility of the following equation.  |  | | --- | | is the periodicity of the PRS RSTD measurement in positioning frequency layer i for the jth set of PRS processing capability defined as: | |
| Lenovo [19] | **Proposal 4:** Introduce additional T values for UE (N,T) processing capabilities. FFS suitable T values that meet <10 ms requirement. |

## Round 1

Based on the input, the FL has the following initial tentative proposals.

### Proposal 9.1-1

* Further study the benefit of introducing additional UE PRS processing capability(ies) for the purpose of latency reduction.
  + Note: UE PRS processing capability without MG is a separate issue.

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| **Company** | **Yes/No** | **Comments** |
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## Round 2

# Other proposals

## General information

The proposals from following sources cannot be categorized in the previous aspects, and is only supported by a single source.

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| **Company** | **Proposals** |
| vivo [3] | **Proposal 1:**   * + Physical layer latency reduction should be independent of scheduled location time.   + The method with scheduled location time can be considered as a further optimization to be discussed in Rel-17 if scheduled location time is supported. |
| Nokia [7] | **Proposal 7:** RAN1 should study mechanisms for controlling and/or assessing the way the UE performs positioning measurements, e.g. how flexible the beamed IF measurement is, and how long each measurement gap needs to be.  **Proposal 8:** RAN 1 should study solutions which can accommodate a reduced positioning session, in the sense that they allow for a reduced measurement report from UE, based on the RX beam information of the UE.  **Proposal 9***:* RAN 1 should study mechanisms and/or revise the current SRS transmission/reception procedure to optimize for latency, particularly for higher carrier frequencies and for densely populated cells. |
| Qualcomm [10] | **Proposal 6:** For low latency positioning, support a UE to report as a UE capability the for the case that the UE receives a low-latency positioning request. |
| IDC [14] | **Proposal 7:** Support dynamic muting of PRS. |
| Xiaomi [18] | **Proposal 9:** To indicate the first arrival path by reporting the arrival time of each beam in beam measurement report. |
| Ericsson [20] | **Proposal 4** Do not support lower PRS periodicities for DL PRS in rel17.   * + Note: periodicity of measurement reporting is a separate discussion |

## Round 1

For some proposals, it is difficult for the FL to understand the motivation, so the FL is requesting proponents to offer suggestions on how to merge the proposal with the previous discussion points. Otherwise, it is generally encouraged for other interested companies to bring the issue in future meeting.

### Suggestions from proponents

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| **Company** | **Yes/No** | **Comments** |
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## Round 2

# Conclusion