**3GPP TSG RAN WG1 #105-e  R1-2105989**

**e-Meeting, May 10th – May 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#105-e, the following contributions provided input on latency improvements for DL and DL+UL methods.

1. R1-2104280 Positioning latency enhancements Huawei, HiSilicon
2. R1-2104362 Discussion on latency enhancement for NR positioning vivo
3. R1-2104523 Discussion on latency improvements for both DL and DL+UL positioning methods CATT
4. R1-2104593 Discussion on latency reduction for NR positioning ZTE
5. R1-2104614 Discussion on latency improvement for positioning CMCC
6. R1-2104674 Enhancements for Latency Improvements for Positioning Qualcomm Incorporated
7. R1-2104742 Enhancements on Latency Reduction in NR Positioning OPPO
8. R1-2104874 Discussion on latency improvements for DL and DL+UL positioning methods InterDigital, Inc.
9. R1-2104908 NR Positioning Latency Reduction Intel Corporation
10. R1-2105108 Views on Rel-17 positioning latency reduction Apple
11. R1-2105171 Considerations on Latency Improvements for DL and DL+UL positioning methods Sony
12. R1-2105313 Discussion on latency improvements for both DL and DL+UL positioning methods Samsung
13. R1-2105485 Discussion on latency improvements for NR positioning LG Electronics
14. R1-2105515 Views on PHY Latency Reductions Nokia, Nokia Shanghai Bell
15. R1-2105564 Latency improvements for both DL and DL+UL positioning method Xiaomi
16. R1-2105760 Aspects for physical latency improvement MediaTek Inc.
17. R1-2105861 Positioning Latency Reduction Enhancements Lenovo, Motorola Mobility
18. R1-2105911 Latency improvements for both DL and DL+UL positioning methods Ericsson

This paper provides the summary of the solutions to improve positioning latency for DL and DL+UL methods, in the following email discussion assignment in RAN1#105-e.

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

# Scheduling location in advance

## Summary of views based on t-doc submission

The summary based on inputs from contributions is given below.

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| vivo [2] | 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.
 |
| Qualcomm [6] | Proposal 1: Send a draft Reply LS: * RAN1 thanks SA2 for their LS on Scheduling Location in Advance to reduce Latency.
* RAN1 discussed the subject matter and agrees that scheduling location in advance is within the positioning enhancement work item objective, and RAN1 will target supporting this feature in Rel-17 positioning enhancement time frame in alignment with the CR received from SA2.

Proposal 2: For UE-based positioning, a UE is expected to report a location estimate which is valid for the requested “Location Time”.Proposal 3: For UE-assisted/network-based Positioning, support LMF sending a “Time-domain Window” configuration(s) to both UE and gNBs that define the time at which the measurements are expected to be obtained. * Each window is defined with a start/End configuration
* If startTime is provided, the device (UE/gNB) is expected to perform measurements and reporting that start no earlier than the startTime.
* If EndTime is provided, the device (UE/gNB) is expected to perform measurements no later than the EndTime.

Proposal 4: With regards to the requested Time-domain measurement Window: * Study further the UE behavior when a limited number (or none) of PRS instances appears within a configured time-domain window.
 |
| Intel [9] | Proposal 4: * For NR positioning latency reduction,
	+ Continue discussion on scheduling location and DCI based signaling mechanism once more details are clarified by SA2 with respect to definition and potential pre-configuration of scheduling location information for NR positioning
 |

## Scheduling location in advance and reply LS

As per Chairman’s assessment, the discussion regarding the incoming LS from SA2 and RAN2 is to be handled in another thread. The summary and comments with respect to the aspect is suggested to be handled in that thread.

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| Related to R1-2102306 (LS on Scheduling Location in Advance to reduce Latency, SA2, Qualcomm)Related contributions:* [R1-2104643](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_105%5CDocs%5CR1-2104643.zip) Draft reply LS to SA2 on Scheduling Location in Advance Qualcomm Incorporated
* [R1-2105937](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_105%5CDocs%5CR1-2105937.zip) Discussion on scheduling location in advance to reduce latency Huawei, HiSilicon

Initial assessment:* Postponed from RAN1#104b-e. Email discussion/approval for the reply LS till 5/25, to be handled under 8.5 (name TBD, Qualcomm)

|  |  |
| --- | --- |
| **Company** | **Views** |
| ZTE | In our view, this topic is irrelevant of positioning latency reduction. The scheduled location time is more like a location information report that should be reported at a specific time, which may be implemented by configuring a proper response time for the location information report. It may have spec impact in RAN2. Therefore, we agree with FL’s initial assessment. |
| vivo | OK |

 |

### Round 1

### Proposal 1.1.1-1 for conclusion:

* The related discussion on the scheduling location in advance is to be handled in the LS-dedicated email thread.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE | Agree |  |
| vivo | Yes |  |
| OPPO | Ok |  |
| Lenovo,Motorola Mobility | Yes |  |
| CATT | Yes |  |
| Ericsson | Yes |  |
| Qualcomm | OK |  |
| Xiaomi | Yes |  |
| LG | Agree |  |

# PRS measurement time reduction

## Summary of views based on t-doc submission

The summary based on inputs from contributions is given below, which may include common aspects for reducing latency in MG-based and MG-less PRS measurements.

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| Huawei, HiSilicon [1] | Proposal 1: The latency enhancement on measurement time reduction should focus on* Another set of (N, T) with N being the slot duration
* Reduce the PRS measurement sample time as defined by RAN4 to [1] for high SNR.
 |
| vivo [2] | Proposal 2: * Send an LS to ask RAN4 whether Nsample=1 is feasible for DL PRS measurement.

Proposal 12: * The request of the measurement via RRC signaling, MAC-CE and/or physical layer procedure should be supported.

Proposal 13: * Priority rules should be supported for the processing/reception of DL PRS and other signals/channels or sharing MG.

Proposal 14: * Priority rules for positioning measurement and report should be supported in Rel-17 positioning.
 |
| CATT [3] | Proposal 1: A-periodic PRS and semi-persistent 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: In multiple gNB positioning, UE can be triggered to receive AP-PRS through LMF message.Proposal 3: In multiple gNB positioning, UE can be triggered to receive periodic PRS through the DCI or MAC CE to reduce the latency.Proposal 4: To reduce the measurement latency, support LMF to inform serving gNB when the UE will report location measurement result. The serving gNB should send the UL grant to UE before the measurement gap, which schedules the UL resource for the UE to send the measurement report in the proper time right after the measurement gap.  |
| ZTE [4] | Proposal 1: In order to reduce UE measurement time of a location information report, LMF should be allowed to select/configure 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.Proposal 4: In Rel-17, some parameters (e.g. UE Rx beam sweeping factor and the number of samples) in measurement period should be configurable, if possible, reported by UE. |
| Qualcomm [6] | Proposal 2: For UE-based positioning, a UE is expected to report a location estimate which is valid for the requested “Location Time”.Proposal 3: For UE-assisted/network-based Positioning, support LMF sending a “Time-domain Window” configuration(s) to both UE and gNBs that define the time at which the measurements are expected to be obtained. * Each window is defined with a start/End configuration
* If startTime is provided, the device (UE/gNB) is expected to perform measurements and reporting that start no earlier than the startTime.
* If EndTime is provided, the device (UE/gNB) is expected to perform measurements no later than the EndTime.

Proposal 4: With regards to the requested Time-domain measurement Window: * Study further the UE behavior when a limited number (or none) of PRS instances appears within a configured time-domain window.

Proposal 5: Support single-sample measurements in NR Rel-17 with the following details: * Single-sample measurements correspond to RSTD/RSRP/Rx-Tx measurements performed within a single DL PRS period and a single Measurement Gap (MG).
* Introduce new UE capabilities for supporting this low-latency Positioning feature
* Send LS to RAN4 to study relaxed accuracy & measurement period requirements (if needed) for the case of single-sample PRS processing.

Proposal 6: For the scenario of single-sample PRS processing, at least from RAN1 perspective, define the UE “Processing Time” of a PRS sample as follows:* The start time is the time after the end of the last PRS resource of the PRS sample
* The end time corresponds to the earliest time after which the UE is capable of reporting Positioning measurements derived from the PRS sample
* FFS: Relation of the “Processing Time” to the already existing (N,T) capability in NR Rel-16

Proposal 7: Send an LS to RAN2 to ask them to introduce responseTime at least as small as 100msec. Study further whether smaller values could be feasible in this release. Proposal 8: Support explicit signaling requesting from a UE to perform positioning measurements with a fast processing timeline. * FFS: Whether the “Time-domain Window” configuration could be used for this purpose.
 |
| Intel [9] | Proposal 3: * For NR positioning latency reduction,
	+ Further consider DCI based mechanism for indication of DL PRS transmission in a given transmission period/occasion based on pre-configured DL PRS configuration/resources
	+ Further consider support of DL PRS measurement and report for single DL PRS period/occasion
	+ Further analyze UE DL PRS processing capabilities aiming to reduce latency of DL PRS measurement time including possibility of simultaneous processing across multiple DL PRS frequency layers
 |
| Apple [10] | Proposal 4: 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
 |
| Sumsung [12] | Proposal 1: The configured grant PUSCH type 1 and type 2 could be considered for positioning measurement report to reduce the latency.Proposal 2: The DG PUSCH with high priority could be considered for positioning measurement report to reduce the latency. |
| LGE [13] | Proposal 2:* In order to reduce physical layer latency in grant based DL-positioning measurement, following potential enhancements can be included:
	+ Transmission of measurement gap request message including scheduling request and/or BSR
	+ Transmission of measurement gap configuration message accompanied by UL grant
	+ Transmission of UL grant without scheduling request in accordance with predefined rule
 |
| Nokia, NSB [14] | Proposal 1: UE could request the expected measurement report resource from the serving gNB via RRC signaling to minimize the positioning measurement report delay.Proposal 3: 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 4: 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. |
| Xiaomi [15] | 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 3: Support PRS measurement report by PUSCH including configured grant PUSCH and dynamic grant PUSCH.Proposal 4: Support triggering of on-demand measurement gap by MAC CE or DCI, and the triggering of on-demand PRS and PUSCH resource allocation for PRS measurement report can be indicated by the same DCI. |
| MediaTek [16] | Proposal 2-1: After UE decodes the PDSCH for receiving the message of location information request, UE may request aperiodic PRS transmission, if the waiting time is long for a periodic PRS occasionProposal 2-2: Aperiodic PRS transmission may be confined to the scenario that the transmission being from the serving gNB and the corresponding TRPsProposal 3-2: Similar to SMTC, the PMTC, PRS measurement timing configuration, could be introduced. Generally, the latency could be improved when PMTC is partially overlapping with MGs and PMTC period < MGRPProposal 3-3: Transition symbols before and after a PMTC duration could be considered, and there is no data transmission within these transition symbols |
| Lenovo, MotM [17] | Proposal 1: Introduce additional T values for UE (N,T) processing capabilities. FFS suitable T values that meet <10 ms requirement.Proposal 2: RAN1 to recommend suitable response times based on at least the following factors:* UE’s capabilities
* Based on immediate and periodic reporting
* Required end-to-end positioning latency budget by LCS client at LMF.

FFS response time values that align with the latency requirements and UE measurement capabilities. Notify RAN2 via LS regarding recommended response times based on feasible processing times in physical layer.Proposal 6: gNB and LMF can align on the expected delay related to the request and application of the MG configuration in order to adapt the UE response time accordingly. May involve further work in RAN2/RAN3. |
| Ericsson [18] | Proposal 3 Support measurement reports for RSRP and RSTD based on a single PRS measurement, i.e. N\_sample= 1. |

Based on the summary, the following issues are identified.

* Single-sample PRS measurement
* Response time and early fix report
* Measurement reporting resource
* AP/SP PRS and measurement request/report in lower layers
* PRS-PRS processing priority
* PRS measurement window configuration
* A new (N, T) for low processing latency

## Single-sample PRS measurement

A couple of sources (Huawei [1], vivo [2], ZTE [5], Qualcomm [6], Intel [7], Ericsson [18]) proposed single-sample PRS measurements.

In particular,

* Huawei [1] mentioned that the applicability of single sample measurement should be high SNR.
* vivo [2], Qualcomm [6] also proposed to send an LS to RAN4.
* Qualcomm [6] additionally proposed to define “PRS sample processing time”.

### Round 1

Based on the summary, the FL has the following tentative proposal.

### Proposal 2.1.1-1:

* Single sample PRS processing subject to UE capability is supported from RAN1 perspective.
* FFS other sample numbers.
* FFS signaling details.
* FFS whether the PRS sample processing time is defined and the relation with (N, T).
* Send an LS to RAN4 on the feasibility and the aspects on accuracy and measurement requirement.

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| **Company** | **Yes/No** | **Comments** |
| ZTE | Agree in principle. | Suggest to revise the main bullet and add another FFS since whether this should be UE capability or simply configured by LMF can be further discussed.* Single sample PRS processing ~~subject to UE capability~~ is supported from RAN1 perspective.
* FFS details of UE capability

In addition, other default values in measurement period requirement should also be considered. For example, Rx beam sweeping factor is default to be 8 in FR2, which also contributes a lot to measurement time. |
| vivo |  | We would like to know the difference between “one measurement instances” in AI 8.5.1 and “Single sample PRS processing” hereIf it is similar, maybe we should avoid duplication.

|  |
| --- |
| Agreement:Support enabling* A UE to report one or more measurement instances (of RSTD, DL RSRP, and/or UE Rx-Tx time difference measurements) in a single measurement report to LMF for UE-assisted positioning, and
* A TRP to report one or more measurement instances (of RTOA, UL RSRP, and/or gNB Rx-Tx time difference measurements) in a single measurement report to LMF, and
* Each measurement instance is reported with its own timestamp
	+ FFS: The measurement instances are within a [configured] measurement time window
* FFS: Each UE measurement instance can be configured with N instances of the DL-PRS Resource Set
	+ FFS: N (including N=1)
* FFS: Each TRP measurement instance can be configured with M SRS measurement time occasions
	+ FFS: M (including M=1)
* FFS: details of signalling, procedures, and UE capability if any
* FFS: whether and how to consider the additional enhancement related to measurement reporting of multi-paths and quality metric
* Note 1: A measurement instance refers to one or more measurements, which can either be the same or different types, which are obtained from the same DL PRS resource(s), or the same UL SRS resource(s).
* Note 2: This enhancement has no intention to change the mapping of measurement types to Rel-16 positioning techniques and no intention to introduce new positioning techniques either.
 |

 |
| CMCC |  | We share similar views with vivo that enabling single sample PRS measurement is the same issue discussed in measurement instance enhancement in AI 8.5.1. |
| OPPO | No | The definition of “single sample PRS processing” is not clear. Does it mean the UE only measure one PRS resource, which is obviously not right because the UE has to measure PRS resource from multiple TRPs to calculate the RSTD or DL-AoD measurement.Or does it mean that for each PRS resource, the UE only measures one transmission sameple. If so, it seems it up to UE implementation and we do not spec change for that. |
| Lenovo,Motorola Mobility | Yes | Support FL’s proposal in that a single PRS sample can flexibly reduce positioning latency. We would like clarification on PRS sample processing time since based on our understanding this refers to the post-processing time, which falls within the T duration of the (N,T) UE PRS processing capability, i.e. T-N.  |
| MTK | Yes in principle | 1,We also think single sample measurement = measurement instance equal to 1. So we also suggest to use the wording already in 8.5.12, RAN4 defines average number = 4, and it is also related to the side condition (SNR) for the test. We also agree to send LS to RAN4, and RAN4 may check side condition for measurement instance equal to 1 |
| CATT |  | Share the similar view as vivo and CMCC, assume one sample in RAN4’s spec implies the measure of one instance of the DL-PRS Resource Set. |
| Ericsson | Yes | Support. We agree with MTK that an LS to RAN4 is needed to identify the impact on requirements/side condition.  |
| Qualcomm | Yes | Our understanding is that the wording “sample” is used according to the discussion in RAN4. We tried to clarify it in our paper by saying:* Single-sample measurements correspond to measurements performed within a single DL PRS period on a PRS resource.

It is similar topic as in 8.5.1, but we need to make an agreement at one subagenda and mot keep moving it around.At least it is easy to understand that it helps with reduced latency, so we are OK to discuss it here.  |
| Huawei, HiSilicon | Yes | To our understanding, whether single sample reporting is supported is orthogonal to the discussion in 8.5.1, because each measurement instance may contain more than 1 samples subject to RAN4 consideration. |
| Xiaomi | Yes in principle  | We agree that it is necessary to clarify the single sample PRS first and the impact on accuracy should be considerd. |
| ZTE |  | We tend to agree the understanding of sample as Qualcomm,* Single-sample measurements correspond to measurements performed within a single DL PRS period on a PRS resource. E.g. UE only has to measure a single DL PRS period on a periodic PRS resource before the response time, so UE doesn’t need to measure multiple instances (or samples) for a periodic DL PRS. By this way, LMF can configure a smaller value of response time so that LMF can quick response.

Our understanding is that this should decouple with discussion in 8.5.1. The topic in 8.5.1 is to address timing error shift, not for latency reduction, UE may have to measure multiple instances (or samples) of a periodic DL PRS even in a single measurement instance. |
| LG | YES | We are generally fine with FL’s proposal.  |

## Response time and early fix report

A couple of sources (ZTE [4], Qualcomm [6], Lenovo [17]) proposed to enhance the response time and early fix enhancements. For the response time, the enhancement seems quite straightforward, while for the early fix enhancements, given the fact that this is the best-effort category, whether UE processing for early fix should be specified would require additional study.

### Round 1

Based on the summary, the FL has the following tentative proposal.

### Proposal 2.2.1-1:

* Support 100ms granularity for location response time.
* FFS other granularities.
* FFS mechanisms to adapt the UE response time
* FFS whether and how early fix report is enhanced.

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE | Agree in principle. | For us, it’s important to enhance early fix report so that UE can report buffered measurement results as soon as possible. |
| Vivo | Yes |  |
| CMCC |  | We believe that this enhancement should be discussed in RAN2 WG. |
| OPPO | Ok in principle | That should be UE capabity |
| Lenovo,Motorola Mobility | Yes | RAN2 is also discussing this aspect in parallel so any related RAN1 agreements can be sent via an LS. Support a finer granularity in the location response time since the current 1000ms in sufficient based on the current Rel-17 requirements. On the first bullet point, we would like to confirm if the 100ms granularity refers to a value range of [0-1000ms] in steps of 100ms? |
| CATT | Yes in principle | We may also need to consider the case when UE could not provide the reliable measurements or even no measurement within the responseTime given that the response time is reduced to 100ms or even smaller. |
| Ericsson | No | We have a similar view as CMCC. We don’t see this as in RAN1 scope.  |
| QC | Yes | To address Ericsson/CMCC, what if we send an LS to RAN2 and tell them that: From RAN1 perspecitive it is beneficial to Support a finer granularity for location response time. Details up to RAN2.  |
| Huawei, HiSilicon | Yes |  |
| Xiaomi | Yes in principle  |  |
| Samsung  |  | Ok with QC’s suggestion. But again, it could be also totally upto RAN2. |
| LG | Agree in principle |  |

## Measurement reporting resource

A couple of sources (CATT [3], Apple [10], Samsung [12], LGE [13], Xiaomi [15]) proposed to define a prescheduled UL resources to carry the LPP measurement report so that UE is not required to perform SR/BSR when the measurement results are ready.

Sumsung [12] also mentioned the priority of the DG-PUSCH should be high to reduce the latency

### Round 1

Based on the summary, the FL has the following tentative proposal.

### Proposal 2.3.1-1:

* Support the enhancement on PUSCH scheduling to carry the LPP measurement report
	+ Option 1: Signaling from LMF to the gNB to facilitate the PUSCH scheduling
	+ Option 2: Signaling from UE to the gNB to facilitate the PUSCH scheduling
		- FFS: The signaling from UE to the gNB can be a measurement gap request multiplexed with SR/BSR
	+ FFS: The preschedule PUSCH can be CG-PUSCH or DG-PUSCH
	+ FFS: The priority of the PUSCH
	+ FFS: The configuration/scheduling of the PUSCH is accompanied with measurement gap configuration or PRS measurement BWP switching information (if supported)

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | Not sure if this is within the scope for ”the time needed to perform UE measurements”. This proposal is talking about how UE can report measurement rather that the time needed for UE to get measurement results.In addition, location information is reported to LMF via LPP in high layer signaling. We think it’s up to implementation to decide which physical channel can report the location information. |
| vivo | Yes |  |
| InterDigital | Yes | We agree that timely measurement report delivery is important for latency reduction. |
| CMCC | Yes |  |
| OPPO | No | Share the same understanding as ZTE that this issue if out of scope.And the LPP report is higher layer signalling on top of RAN. The air interface only provide carrier for that. We should not touch the physical layer signalling for that |
| Lenovo,Motorola Mobility | Yes  | Currently L1 is transparent to the transmission of the measurement report based on available UL resources configured by the gNB. Option 1 may have lower spec impact since the LMF and gNB can align on the CG periodicities and LPP periodic intervals of measurement reporting, which can apply to measurements with/without a measurement gap.  |
| MTK |  | We think RAN2 is prioritized to deal with the latency reduction through reporting* Specify the enhancements of signalling, and procedures for improving positioning latency of the Rel-16 NR positioning methods, for DL and DL+UL positioning methods, including:
	+ Latency reduction related to the request and response of location measurements or location estimate and positioning assistance data; [RAN2, RAN3, RAN1]
 |
| CATT | Yes.  | Prescheduled UL resources for the LPP measurement report seems to be important for reducing the latency for some scenarios. |
| Ericsson | No | We do not see this to be in RAN1 scope. RAN2/3 should probably lead the discussion.  |
| Qualcomm | No | This is not within WID scope from RAN1 perspective |
| SONY | Yes |  |
| Huawei, HiSilicon | No | We think at least RAN2 should be consulted.* For DG, how SR/BSR are triggered needs to consult MAC experts. Basically UE cannot send SR if the buffer is empty, or report the future BSR.
* How the higher layer PDUs are assembled need to consult MAC experts also. Different logical channels have different priorities, and assembly procedure is real-time.
* For CG, the periodic UL traffic report to gNB can be studied by RAN2, including SDT.

Two questions from our side is that* How would UE/LMF know the payload of the LPP before the measurement results is ready?
* How would UE/LMF know if other PDUs other than LPP arrives at the time of PUSCH scheduling?
 |
| Xiaomi | Yes  | Preconfigured UL resource for reporting can reduce the latency  |
| Samsung  | yes | RAN2 of course should look into this reporting procedure that’s why RAN2 is listed as leading group for this bullet in WID.From our point of view, discussing and decide possible resource configuration is RAN1 job and apparently having optimized resource configuration could be benefitial for latecy reduction. To the options, we think both option can be considered at least for now. the option1 can be suitable for gNB configured CG based PUSCH, option2 is more suitable for DG PUSCH.For the question from HW:1. it may or maynot (exactly) know depends on the information to report, e.g., if the number of reporting results are known, even without knowing the exact measurement value, the needed size of the report could be known. But if the measurement time and information is somehow dynamic, it might be difficult, a reference size could be given and or the adjustable MCS could be considered.2. for scheduling a data, different logical channel will request separate resoruces, once RAN2/MAC decides that for positioning reporting, a given scheduling requestion procedure could be triggered, it will not be impacted. Current 16 HARQ process seems enough. |
| LG | Agree | Based on current LPP specificiation, UE can know which measurement result is provided for LMF when UE receives LPP message (e.g. RequestLocationInformation). So, we think that additional enhancements by using the information can be useful for latency reduction. In this respect, we agree with FL’s proposal. |

## Aperiodic PRS, semi-persistent PRS, and measurement request/report in lower layer

A couple of sources (CATT [3], Xiaomi [15], MediaTek [16]) proposed to support AP/SP PRS.

A couple of sources (vivo [2], CATT[3], Intel [9]) proposed to support measurement request and report in lower layers (e.g. MAC-CE, DCI).

According the understanding of the FL based on the RAN#91-e discussion, AP/SP SRS are not included in the WID and the feasibility of lower layer handling of the positioning measurement is in question given the current LCS architecture is reused.

### Round 1

Companies are encouraged to provide views on the following tentative proposals.

### Proposal 2.4.1-1:

* RAN1 to confirm whether support of AP/SP PRS is in the WID of Rel-17 positioning.

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | Out of scope. It can be discussed in future release. |
| InterDigital | Yes | Semi-persistent and aperiodic PRS enable latency reduction. |
| CMCC | Yes | We are OK to confirm the WI scope regarding AP/SP PRS, and we are supportive of this enhancement. In our view, the time domain resource type of the DL PRS can be enhanced to be AP and SP, which can be semi-statically configured by higher layers and dynamically activated/triggerd according to the positioning requirements. |
| OPPO | NO | It is out of scope. |
| CATT | Yes | Our understanding the support of AP/SP PRS is fundamental for reducing the latency and also for the support of on-demand PRS. Although AP/SP SRS is not included in the WID due to the implementation issue, there was no discussion/conclusion of excluding AP/SP PRS. |
| Ericsson | No | This was discussed during the SI phase and we did not include this in the WID. In our view this is out of scope.  |
| Qualcomm | No | Even though we are supportive of the features, procedurally speaking we are under the understanding that it was removed from the WID of rel-17.  |
| SONY | Yes | This can be related to on-demand positioning. |
| Huaewi, HiSilicon | No | We do not think that it is the WID. |
| Xiaomi | Yes  | AP/SP PRS can be supported to reduce the latency and it is related to on-demand PRS.  |
| LG | Yes | In terms of latency reduction, we believe that it is usefult. |

### Proposal 2.4.1-2:

* RAN1 to confirm whether support of measurement request and report in lower layers is in the WID of Rel-17 positioning.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | Out of scope. It can be discussed in future release. |
| Vivo | Yes | According to the following WID and the agreement, the latency reduction on measurement request and report is in the WI and should be discussed.

|  |
| --- |
| * Specify the enhancements of ignaling, and procedures for improving positioning latency of the Rel-16 NR positioning methods, for DL and DL+UL positioning methods, including:
	+ Latency reduction related to the request and response of location measurements or location estimate and positioning assistance data; [RAN2, RAN3, RAN1]
	+ Latency reduction related to the time needed to perform UE measurements; [RAN1, RAN4]
	+ Latency reduction related to the measurement gap; [RAN1, RAN4, RAN2]

Agreement:Capture the following in the TR:* The enhancements of signaling & procedures for reducing NR positioning latency are recommended for normative work, including DL and DL+UL positioning methods
	+ The details of the solutions are left for further discussion in normative work, which may include the following aspects:
		- Latency reduction related to the measurement gap
		- Latency reduction related to the reporting and request of the measurements (e.g., via RRC signaling, MAC-CE and/or physical layer procedure, and/or priority rules)
		- Latency reduction related to measurement time
 |

So, we propose to revise the proposal as followsProposal 2.4.1-2:Study the following options for latency reduction related to the request and response of location measurements or location estimate* measurement request and report in lower layers (e.g. MAC-CE, DCI)
* priority rules of measurement request and report
 |
| CMCC | Yes |  |
| OPPO |  | It has been dicussed and it is our of the scope of WID. For RAN1, we only have this:* Latency reduction related to the time needed to perform UE measurements
 |
| MTK | No | This seems to be useful for local LMF case. And we wonder it could reduce latency significantly for LMF at core network |
| CATT | Yes | Share the similar view of vivo. |
| Ericsson | No | We do not see how to fit such requests in the current positioning architecture and lower the latency. Currently The measurement requests originate in the LMF, so the these requests would have to be forwarded to the gNB, which would in turn send a MAC/CE or DCI to the UE. We don’t see how this would help with latency reduction.  |
| Qualcomm | No | Even though we are generally supportive of the feature, and can really help when we eventually (at some future release) we have LMF in the RAN, at this stage, we believe that this feature is out of scope and can help with latency only of LMF in RAN is supported also.  |
| SONY | Yes | We have similar view as VIVO. |
| Huawei, HiSilicon | No | We think that during the WID discussion, removing the examples of RRC, MAC CE, DCI was intentional because companies felt that no LCS architecture change is expected for Rel-17. |
| Xiaomi | Yes  | We have similar view as vivo. |
| Samsung  | Slightly no | By the wording here, it seems more like localized positioning procedure and architacture.if this is the case, it may involve much more design effort and not finished in this release time.  |
| LG | Agree | Same view of vivo. |

## PRS-PRS processing priority

A couple of sources (vivo [2], ZTE [4], Nokia [14]) proposed to enhance PRS processing priority to reduce latency. Due to limited input, it is advised to further study PRS processing priority in the future meetings.

### Round 1

The FL has the following tentative proposal.

### Proposal 2.5.1-1:

* Further study enhancement on PRS-PRS processing priority.
	+ Option 1: Enhancing Rel-16 PRS priority mechanism.
	+ Option 2: LMF may configure a subset of DL PRS from the assistance data for measurement.
	+ Option 3: LMF may configure a subset of TRPs from the assistance data for measurement.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | Suggest the following revised proposal to make it clearer. In our understanding, this proposal intends to reduce measurement period requirement for a location information report that is based on prioritized DL PRS/a subset of DL PRS/ a subset of TRPs. Therefore, LMF can get quick response from UE.* Further study enhancement on the time needed to measure prioritized DL PRS/a subset of DL PRS/ a subset of TRPs.
	+ Option 1: Enhancing Rel-16 PRS priority mechanism.
	+ Option 2: LMF may configure a subset of DL PRS from the assistance data for a location information report.
	+ Option 3: LMF may configure a subset of TRPs from the assistance data for a location information report.

FFS: Whether/how to determine measurement period requirement for a location information report that is based on prioritized DL PRS/a subset of DL PRS/ a subset of TRPs. |
| vivo | No | First, we are a bit confused about the main bullet, we would like to know what is PRS-PRS processing priority?Secondly, the intention and method should be further clarified for option 3 since the priority of TRP has been supported. Otherwise, we cannot agree with listing the option here.Lastly, we think option2 also is discussed in AI 8.5.3, we propose to avoid duplication. And compared to the LMF configure a subset for measurement to reduce latency, we prefer the PRS selection occurs on the UE side. |
| FL |  | Just to clarify to vivo the intention here that I used “PRS-PRS processing priority” to differentiate “PRS-data/RS processing priority” in section 3.2, because from the contributions, companies proposed to define the priority among PRS to reduce latency. |
| CMCC | No | In our view, all DL PRS configurations are provided by the LMF, not sure why do we need to consider the processing priority between different DL PRS? |
| OPPO | NO | This proposal is not clear. If the priority among all the DL PRS resoucres, we do not think enahcenment is needed. |
| Lenovo,Motorola Mobility | Yes | Support the FL’s proposal in terms of explicit priority indications, which is different from the current implicit mechanism used in Rel-16. Suggest another bullet point “FFS: how the priority is mapped among different PRS resources”. This can also apply to the explicit PRS resources prioritization discussion of adjacent beam reporting in the 8.5.3 DL-AoD AI. |
| CATT |  | We don’t see the strong motivation and benefits to priotized some PRS resouorces over other PRS resources. |
| Ericsson | Maybe  | We see this as a low priority discussion.  |
| Qualcomm | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Xiaomi |  | For Option 1, we want to clarify what is the Rel-16 PRS priority mechanism.For Option 2, it is also discussed in 8.5.3.For Option 3, does it mean that the TRP ID can not be configured by existed signaling?  |
| ZTE |  | To opponents,The measurement period defined in TS 38.133 has to consider all DL PRS configured in ProvideAssistanceData message for a location information report in current design. For a specific location information report, LMF should be able to select a subset of DL PRS from DL PRS in ProvideAssistanceData message for UE to measure and report the location information report. The rationale behind this enhancement is that LMF may have prior information of UE location or channel conditions. Hence, in order to get quick location information report, UE is not necessary to measure all DL PRS configured in ProvideAssistanceData message.We try to decouple the DL PRS in ProvideAssistanceData and ProvideLocationInformation. That is, UE may be configured to report multiple location information reports (identified by different by location information ID), where a location information report may only need to measure a subset of DL PRS configured in ProvideAssistanceData. By this way, the latency to derive a location information report will be reduced. We consider this should be high priority. |
| LG | Agree in principle | For progress, we think that ‘PRS-PRS processing priority’ needs to be clarified first. |

## PRS measurement window configuration

A couple of sources (Qualcomm [6], MediaTek [16]) proposed to introduce the PRS measurement window configuration. Due to limited input, it is advised to further study PRS measurement window configuration in the future meetings.

### Round 1

The FL has the following tentative proposal.

### Proposal 2.6.1-1:

* Further study the PRS measurement window configuration for the purpose of latency reduction.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| vivo | No | We can understand the intention for further study, but in the Tdoc analysis, we found there are many windows, some are for replacing the MG, some are for combing the schedule location time. The window seems different for different companies. So we are concerned about whether it helps for the next work since it is too broad. |
| OPPO |  | The proposal is not clear. Does it intent to dicuss the measurement gap? |
| MTK |  | To FL, our proposal to consider PMTC, which is similar to SMTC, is for the purpose to support measurement outside gaps. Since SSB measurement supports measurement outside gaps, and we think PRS measurement could be quite similar to SSB measurement so that both can be applied a same structure.QC’s proposal seems quite different from ours.  |
| CATT |  | It is unclear to us what the benefits to configure the PRS measurement window here for the purpose of latency reduction. In 8.5.1, there is also a discussion on PRS measurement window but from the purpose of accuracy improvement. |
| Ericsson |  | We see this as a low priority discussion.  |
| Qualcomm | Yes | We think that the proposals may be different between MTK and QCAt least in our proposal, the intention is to make it clear when the UE is expected to do the “measurement” and when it is expected to the “processing”. For low-latency, the UE would need to dedicate all its processing & measurement power to ensure as fast processing as possible. Some companies call this as PRS prioritization over other procedures. We believe that LMF/serving-gNB and UE need to be aligned into when the UE is prioritizing the PRS over other channels/procedures |
| SONY |  | Low priority |
| ZTE |  | Low priority. We may need to define new capabilities for {N,T} rather than a new window. |

## A new (N, T) for low processing latency

A couple of sources (Huawei [1], Lenovo [17]) proposed to add new (N, T) to support low latency PRS processing. Due to limited input, it is advised to further study the new (N, T) in the future meetings.

### Round 1

The FL has the following tentative proposal.

### Proposal 2.7.1-1:

* Further study whether a new set of (N,T) is reported by the UE for the purpose of latency reduction.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Lenovo,Motorola Mobility | Yes | This is a recommended change on supporting new T processing times to support lower latency UE (N,T) capabilities. |
| MTK | Yes | Okay to study. It seems to us that for the first fix, and in order to pursue faster reporting, UE may measure less PRS. The accuracy could be sacrified somehow for first fix. And the accuracy could be improved for next reporting when UE do more measurements. |
| CATT | Yes | We are fine to study it. |
| Ericsson | Yes  | ok to study further.  |
| Qualcomm | Yes |  |
| Huawei, HiSilicon | Yes |  |
| ZTE | Yes | OK for further study. |
| LG | Agree |  |

## Other proposals

Due to limited support among companies, it is encouraged for companies to bring up their views on the following aspects in the next meeting.

* Simultaneous PRS processing across multiple positioning frequency layers [9]
* Mechanism for controlling and/or assessing the way the UE performs positioning measurements [14]

Note that the proposal from [9] is also captured in the discussion of concurrent PRS processing across multiple positioning frequency layers in MG in section 4.4.

# Latency improvements with respect to PRS measurement without MG

## Summary of views based on t-doc submission

The summary based on inputs from contributions is given below.

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| Huawei, HiSilicon [1] | Proposal 3: The enhancement of PRS measurement without gap includes the following aspects* Define a new PRS processing capability (N, T) without a measurement gap
* Define the priority rule between PRS and data/RS for communication for the case without a measurement gap.

Proposal 4: The following existing agreement made in Rel-16 should be the starting point for specifying PRS measurement without gaps. |
| vivo [2] | Proposal 3: * PRS measurement without measurement gap when PRS within active DL BWP should be specified.

Proposal 4: * UE-initiated or LMF- initiated positioning BWP switching should be supported for positioning.

Proposal 5: * Pre-configured BWP should be considered for positioning, e.g. pre-configured BWP can be a special BWP, or associated with positioning service.

Proposal 6: * The following option should be considered for reducing the latency of SCell activation or addition.
	+ Option 1: The PRS measurement independent with SCell configuration (such as special BWP configuration is independent with SCell )
	+ Option 2: The SCell associated with PRS is always activated
	+ Option 3: Combine SCell activation and BWP switching in one signaling (for example, activating SCell and triggering BWP switching by one PDCCH order)
 |
| CATT [3] | Proposal 5: Up to the UE capability, DL PRS measurements without the configuration of the measurement gap should be supported in Rel-17 to reduce the positioning latency. |
| CMCC [5] | Proposal 1: The UE is expected to measure the DL PRS within its active DL BWP without the request and configuration of the measurement gap.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. |
| OPPO [7] | 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* 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. |
| InterDigital [8] | Proposal 1: Measurements and processing of PRS without measurement gap should be supported.Proposal 2: In the presence of no measurement gap, the UE is expected to receive PRS with higher priority, associated with aperiodic or semi-persistent PRS (if supported by 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.Proposal 6: Support dynamic muting of PRS signals. |
| Intel [9] | Proposal 2: * For the case of DL PRS processing without measurement gap to reduce latency of NR positioning further consider
	+ Introduction of DCI signaling indicating DL PRS configuration and triggering UE DL PRS measurement report over a given set of DL PRS occasions/periods for given DL PRS configuration
	+ Study of mechanisms for potential UE switching from/to active DL BWP to/from DL PRS frequency layer or possibility of spectrum and numerology alignment of DL BWP and DL PRS frequency layer
	+ Definition of UE capabilities for DL PRS processing w/o measurement gap configuration
 |
| Apple [10] | Proposal 1: 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 2: 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 3: Once UE receives the indication to switch to Measurement BWP (M-BWP):* Option 1: UE is not expected to receive or transmit data within the M-BWP
* Option 2: subject to UE capability, UE may continue to transmit and receive within M-BWP, but not within the measurement and processing window for PRS receptions
 |
| Xiaomi [15] | Proposal 5: BWP switching can be used for PRS measurement instead of measurement gap.Proposal 7: The priority of PRS should be differentiated for different latency requirement. |
| MediaTek [16] | Proposal 3-1: Support DL-PRS measurement outside the gaps. FFS on details |
| Ericsson [18] | Proposal 1 In NR Rel-17, support DL measurements based on DL PRS without having to request measurement gaps.Proposal 2 Introduce an indicator in the assistance data signalling that the PRSs present in the measurement request can be measured without measurement gaps, if the UE’s active DL BWP coincides with the PRS bandwidth.Proposal 5 For priority of the PRS against other downlink reference signals and channels:* 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.
* 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
 |

Based on the summary, the following issues are identified.

* Generic support of PRS measurement without MG
* PRS-data/RS processing priority
* Positioning dedicated BWP switching
* New PRS processing capabilities

## Generic support of PRS measurement without MG

All sources (Huawei [1], vivo [2], CATT [3], CMCC [5], OPPO [7], InterDigital [8], Intel [9], Apple [10], Xiaomi [15], MediaTek [16], Ericsson [18]) contributing on this aspect support the PRS measurement without MG.

### Round 1

Based on the summary, the FL has the following tentative proposal.

### Proposal 3.1.1-1:

* PRS measurement outside the MGs subject to UE capability is supported in Rel-17.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | OK to further study. |
| vivo | Yes |  |
| InterDigital | Yes | Bypassing MG configuration via RRC enables latency. |
| CMCC | Yes |  |
| OPPO |  | Ok with the proposal in principla. But we shall clarify that: those PRS shall have same numerology and the bandwidth is within the active BWP. |
| MTK | Yes | In earlier Rel-16, RAN1 already agreed to support PRS measurement outside gaps, with the following wording in 38.214-g10,When not configured with a measurement gap, the UE is only required to measure DL PRS within the active DL BWP and with the same numerology as the active DL BWPTherefore, we can first agree “PRS measurement outside gaps”, and then later on we can justify whether the PRS measurement bandwidth could be larger than the active DL BWP |
| CATT | Yes | We assume the intention is to support PRS measurement w/o the configuration of the MGs instead of outside the configured MGs. Thus, suggest changing the proposal to: ● PRS measurement ~~outside~~ without the configuration of MGs subject to UE capability is supported in Rel-17 |
| Ericsson | Yes | Support. Agree with OPPO that the condition to measurements without MG is to be in the same active BWP, with the same numerology.  |
| Qualcomm | NO | We have a few aspects that we believe need to be understood/addressed with regards to PRS measurement without MG: * Companies argue that MG-less PRS should be supported to reduce the latency of UE requesting MG. But then, how would the gNB know which active BWP should be configured to the UE in order to do the measurements?
	+ If the answer is: UE-initiated BWP request, then it will be the same or similar latency as MG request. UE can do MG/BWP request in RRC or UL MAC CE or any other fast-way we want to agree.
	+ If the answer is: LMF-initiated BWP request, then it is the same as MG-initiated request with regards to latency: LMF asks the gNB to tune the UE in a specific BW for a specific time so that the UE can do the measurements. We can do exactly the same for both MG-based or MG-less PRS. No latency difference between the MG/MG-less PRS either.
	+ If the answer is: the UE should just measure the part of the active BWP that intersects with the PRS BW, then this feature is rather limited, since the procedures are missing into how the gNB will know which BWP should it configure. The serving gNB doesn’t really know where the PRS are transmitted, and a solution is needed into how the feature can be generalized to the case of multiple PFLs or a signle PFL that has different BW than the active BWP.
		- It should be noted that we can do the same for the MG-based PRS: UE autonomously tunes away of the active BWP, measures PRS, and then tunes back. That is, autonomous MG (or PRS processing). Other channels/procedures will be affected, but the LMF can inform the gNB when this is going to happen.
		- So again, MG or MG-less PRS results to similar latency.
* Furthermore, if the intention to introduce MG-less PRS is to reduce lantecy, this would mean that the UE would have to dedicate all its processing power to do the fast processing, so we would need to define a “processing/priortization window” wherein the PRS is prioritized over any other RS, data, CSI (seems also related to Proposal 3.2). This is very similar to having a MG, since the UE will not be able to do anything else until it has reported back the measurements. In other words, we would be operating as if we are within MG, but with the reduced flexibility of tuning to the most appropriate BW. Again, no latency difference.
* Several MG enhancements are being considered (e.g. pre-configured MG, or multiple MG, or Positioning-specific MG), all of which will help with latency reduction. These are also added in this summary in Section 4.1-4.4. If these are specified, can really a MG-less PRS processing be lower latency? And if yes, can a proponent provide a side-by-side comparison why the MG-based PRS cannot be optimized in a similar way as a MG-less PRS with respect to latency reduction?
* Furthermore, doing processing within a MG, allows the PRS to be defined anywhere in the band, not really restricted in the CC-boundaries. If we have BWP-only processing, we would be restricted within the CC-boundaries. This is an argument of keeping MG-based PRS.

All these are some points that we would like to point out to the group, and hopefully will help to nail down how can we really benefit from introducing an MG-less PRS instead of just optimizing the MG-based PRS. We would value some discussion/comparison, *NOT* with the Rel-16 MG-based PRS, but a comparison between the lowest-latency MG-less PRS processing that can be achieved vs. the lowest-latency MG-based PRS processing that can be achieved.  |
| Huawei, HiSilicon | Yes | Reply to QC:The benefit of introducing MG-less PRS measurement can be optunistic, because LMF may not know the UE active DL BWP, and gNB may not know the PRS that UE is to measure. However, there exists the case that a full DL BWP is configured to the UE (and activated), and all the PRS UE is about to receive is from the cells on the same frequency as the serving cell and is with the same numerology of the active DL BWP. Do Qualcomm aknowledge that the scenario can be a quite common?UE can do PRS measurement similar to intra-frequency RRM without requesting MG.As for details, we can further discuss* Conditions when UE should go with MG-less and when UE should request MG
* UE processing capability
* PRS-data processing priority/scheduling restriction
* Whether a BWP switching is needed.
 |
| Xiaomi | Yes  |  |

## PRS-data/RS processing priority

Majority of sources (Huawei [1], CMCC [5], OPPO [7], InterDigital [8], Xiaomi [15], Ericsson [18]) contributing on this aspect discussed the priority rules between PRS and data/RS processing for the cases without MG.

In particular,

* Huawei [1] listed the agreement made in Rel-16 and suggested that those agreement should be the starting point.
* CMCC [5] proposed to support processing PRS and DL signals/channels on the same OFDM symbol.
* OPPO [7] proposed to prioritize PRS over other DL channels and reference signals, except SSB, in which case the priority can be indicated.
* InterDigital [8] proposed to prioritize AP/SP PRS over other DL channels.
* Xiaomi [15] proposed that the priority of PRS should be differentiated for different latency requirements.
* Ericsson [18] proposed that the priority between PRS from the serving cell and PDSCH/CSI-RS (from the serving cell) is handled by priority indicators, while the handling PRS from non-serving cells should be in the MG.

### Round 1

Based on the summary, the FL has the following tentative proposals.

### Proposal 3.2.1-1:

* RAN1 to specify UE behaviour for PRS processing on the same symbol as data and other RS for PRS measurement outside MG
	+ Option 1: UE can process PRS and data/other RS simultaneously
	+ Option 2: Priority rules between PRS and data/other RS are defined
		- FFS the concerned PRS is only from the serving cell or from both the serving and the non-serving cells
		- FFS the priority rule is hardcoded or indicated

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | We think this is further details once Proposal 3.1.1-1 is agreed. Suggest to postpone the discussion. |
| vivo | Yes |  |
| InterDigital | Yes | We should agree on the prioirity rules for PRS transmitted outside of MG. |
| CMCC | Yes |  |
| OPPO |  | Two options are listed here. Are we going to support both? We are not ok with Option 1. Option 2 can be further dicussed. |
| MTK | Yes under condition | We should wait whether 3.1.1-1 is agreed or not (same view as ZTE)If 3.1.1-1 is agreed, we prefer option 2. |
| CATT | Yes | Whether to specify priority rules between PRS and data/RS processing were discussed intensively during the SI for reducing the positioning lantency. |
| Ericsson | yes | Ok to discuss the two options further. We see that both options could be valid, depending on the UE capability. On the FFS for option 2, our view is that the solution in option 2 only applies when the PRS and data are from a serving cell. Regarding indicating or hard-coding the priority rule, we think the data can have different priority so the rule of priority w.r.t. the PRS should be configurable.  |
| Qualcomm | No | Not OK for Option 1. PRS is only TDMed with other channels. independent of whether PRS is within MG or not. Also, for fast PRS processing, a UE may be required to drop the DL channels after the PRS until the PRS report has been sent out.  |
| Sony | Yes |  |
| Huawei, HiSilicon | Yes | We think Option 1 can be further studied, but not necessarily precluded from the first meeting. |
| Xiaomi | Yes  | Prefer Option 2 |
| Samsung  |  | Maybe this can be subjective to UE capability or other conditions? |
| LG | Agree in principle | We are on the same page with ZTE. |

### Proposal 3.2.1-2:

* RAN1 to confirm whether the following agreement made in Rel-16 should be the starting point.

|  |
| --- |
| Agreement: (RAN1#99)In case DL PRS Resources are processed in the active BWP and there is no measurement gap configured to the UE, at least in FR2, the UE is not expected to process DL PRS in the same OFDM symbol where other DL signals and channels are transmitted to the UE. Behaviour in FR1 is up to RAN4 to decide.* Include this agreement in an LS to RAN4.
 |

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | Similar comment as Proposal 3.2.1-1. |
| vivo |  | We wonder about the connection of proposal 3.2.1-1 and proposal 3.2.1-2. In our view, it seems a sub-option of option 2 that PRS is a low priority in FR2, and the priority of PRS in FR1 should be discussed in RAN4. So we wonder what we need to be discussed in proposal 3.2.1-1 if we agree with proposal 3.2.1-2? |
| InterDigital |  | We would also like to clarify the implication of this proposal. Does this proposal mean we consult RAN4 regarding prioritization rules? |
| FL |  | Reply to vivo and IDC:The agreement listed here is what we agreed in Rel-16, and the LS was sent to RAN4 by that time, and we believe that RAN4 already had the discussion on this aspect. The intention of the proposal is check whether companies agreed to reuse the existing agreement (no need for the LS again) or start from ground zero. |
| CMCC |  | Regarding this proposal, does it mean that DL PRS is always de-prioritized when it overlaps with other DL signals/channels in the same symbol (at least in FR2)? Or, it just say that the UE does not process the DL PRS and other DL signals/channels in the same symbol, and priority rule will be further discussed when collision happens? We are ok with the latter understanindg, and to further discuss priority rule as captured in option 2 of Proposal 3.2.1-1. |
| MTK | No | Similar case in RAN4 was to define scheduling availability for intra-freq mobility measurement in 9.2.5.3.3 38.133:“The following scheduling restriction applies due to SS-RSRP or SS-SINR measurement on an FR2 intra-frequency cell The UE is not expected to transmit PUCCH/PUSCH/SRS or receive PDCCH/PDSCH/TRS/CSI-RS for CQI on SSB symbols to be measured, and on 1 data symbol before each consecutive SSB symbols to be measured and 1 data symbol after each consecutive SSB symbols to be measured within SMTC window duration”Which seems to favor SSB measurement. And RAN1’s early agreement seems not to favor PRS measurement.So we prefer not to agree on this   |
| CATT |  | For R17 we prefer the UE processing of DL PRS is not bounded by R16 agreement. |
| Ericsson | yes | We agree that this could be a starting point for the discussion. However, for the the second part of the the sentence, we expect that the possibility to handle priority between PRS and other signal will be discussed in rel-17. As a note, we don’t think we need this to be discussed for a formal agreement in chair notes (but it will help the common understanding during the discussion).  |
| Qualcomm |  | Please see reply before. For Low-latency PRS processing, the UE would have to prioritize PRS processing not only when there is collision with other channels, but also for a period of time after the PRS.  |
| Xiaomi |  | In proposal 3.2.1-2, the PRS is always de-prioritized. But we prefer Option 2 in proposal 3.2.1-1 since we want to define high priority to PRS in some cases.  |
| Samsung  |  | This behavior is not friendly to latency reduction, we can further study how to deal with it. |

## Positioning dedicated BWP switching

A couple of sources (vivo [2], Intel [9], Apple [10], Xiaomi [15]) proposed to support positioning BWP for the cases without measurement gaps.

### Round 1

Based on the inputs from companies, the FL has the following tentative proposal.

### Proposal 3.3.1-1:

* Support switching from the current active BWP to a positioning dedicated BWP for PRS measurement without MG.
	+ FFS configuration of the positioning dedicated BWP
	+ FFS the time duration for the positioning dedicated BWP
	+ FFS triggering of BWP switching
	+ FFS whether data can be received on the positioning dedicated BWP

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | Prefer to further discuss Proposal 3.1.1-1. We don’t need to to be rush to support a method that may have strong impact on scheduling. |
| vivo | Yes |  |
| CMCC |  | We are OK to consider the DL BWP switching enhancement; however, whether a positioning dedicated BWP should be introduced and supported can be further discussed. |
| OPPO | No | We do not support to defined a positioning-dedicated BWP. |
| MTK | Neither Yes nor No | 1, waiting for 3.1.1-1 to be agreed2, if 3.1.1-1 is agreed, we are generally okay for the bandwidth adaptation. We have concern on using “positioning dedicated BWP”. In our view, we don't change the original DL active BWP, which is the range the NW would schedule data to a UE. We just have a larger measurement bandwidth for PRS measurement, and DL active BWP is within the measurement bandwidth, since data is still allowed to be scheduled outside gapsWe propose the following wording, which may be more general: Support bandwidth adaptation such that the PRS measurement bandwidth could be larger than the active DL BWP under measurement outside gaps |
| CATT |  | It seems too early to decide the support of the switching. Our preference is to first have a study on the potential benefits and the impact on the specification before making the decide on whether to support it. |
| Ericsson | No | Do not support. This will not save latency since the UE will have to switch BWP.  |
| Qualcomm | No |  |
| Huawei, HiSilicon | No | The latency would increase to convey the signaling to the gNB with regard to which BWP to switch. |
| Xiaomi |  | We want to clarify that what is the difference between MG and switch to positioning dedicated BWP without data reception? |
| Samsung  | No  |  |
| LG | No |  |

## New PRS processing capabilities

Various sources (Huawei [1], OPPO [7], Intel [9]) proposed to define the UE PRS processing capability without MG. Given the fact that this was discussed in the Rel-16, the enhancement seem quite straightforward.

### Round 1

The FL has the following tentative proposal.

### Proposal 3.4.1-1:

* Define new DL PRS processing capabilities (N, T) for PRS processing outside MG.

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | Similar comment as Proposal 3.2.1-1. |
| Vivo | Yes |  |
| OPPO | Yes |  |
| Lenovo,Motorola Mobility | Yes | Can this be grouped under the general principle of low latency UE capabilities under Proposal 2.7.1-1 ? |
| Ericsson | yes | Support. This can be discuss further at a later stage.  |
| Huawei, HiSilicon | Yes |  |
| Samsung  | Yes. |  |
| LG |  | Similar comment as Proposal 3.2.1-1. |

## Other proposals

Due to limited support among companies, it is encouraged for companies to bring up their views on the following aspects in the next meeting.

* PRS processing with respect SCell activation [2]
* Dynamic muting of PRS [8]
* Indication in the assistance data that the PRS can be measured without MG [18]

# Latency improvements with respect to PRS measurement with MG

## Summary of views based on t-doc submission

The summary based on inputs from contributions is given below.

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| Huawei, HiSilicon [1] | Proposal 2: The measurement gap enhancement for the purpose of PRS measurement can be included in the current RAN4-led measurement gap enhancement WI. |
| vivo [2] | Proposal 7: * Pre-configured MG for positioning should be supported for NR positioning.

Proposal 8: * LMF-initiated pre-configuration and/or activation/deactivation of an MG associated with on-demand PRS needs to be considered in Rel-17.

Proposal 9: * Measurement gap enhancement for concurrent processing multiple positioning frequency layers can be considered.

Proposal 10: * BWP switching can be considered in Rel-17 as an alternative to using measurement gap.

Proposal 11: * MG enhancements, such as pre-configuration MG for positioning, multiple concurrent/ independent MG, and the mechanisms of activation/deactivation of MG following a DCI, should be considered for PRS measurement.
 |
| CATT [3] | Proposal 6: To reduce latency, the aperiodic measurement gap for NR positioning should be introduced.Proposal 7: Support the following methods of the measurement gap configuration for reducing the positioning latency: a) UE/serving gNB informs LMF about the existing measurement gap configuration.b) LMF sends the recommended transmission time of on-demand DL PRS for a UE to the gNBs based on the UE capability of whether to support positioning measurement without measurement gap.c) LMF informs UE of the expected measurement gap before on-demand PRS is configured to UE by LMF.d) LMF sends the recommended measurement gap configuration for a UE to the serving gNB. |
| ZTE [4] | Proposal 5: For the sake of latency reduction related to the measurement gap, Rel-17 should be able to allow LMF to request measurement gap. |
| Qualcomm [6] | Proposal 9: For Measurement gaps shared between Positioning and mobility measurements, support increased priority of processing of Positioning resources when fast PRS processing is configured to the UE.Proposal 10: Support configuring a separate Measurement Gap for the purpose of Positioning only. Send an LS to RAN4 informing them about this agreement. Proposal 11: Consider defining a UE “processing time” within a MG for Positioning during which a UE is expected to finish the processing of the PRS instance transmitted within the “Measurement Time” of the MG. Support configuring SRS for Positioning during the “Processing Time” of the MG for Positioning.* Minimum length of Processing Time shall be [4] msec
 |
| OPPO [7] | Proposal 5: study to support lower-layer signaling based (for example DCI-based or MAC CE-based) measurement gap configuration.Proposal 6: study to support lower-layer signaling based (for example PUCCH-based or MAC-CE based) measurement gap request.Proposal 7: Study to support one triggered measurement gap with multiple repetitions. |
| InterDigital [8] | Proposal 4: Support fast activation of measurement gap via MAC-CE.Proposal 5: Support priority indication for the measurement gap associated with PRS. |
| Intel [9] | Proposal 1: * For the case of DL PRS processing with measurement gap to reduce latency of NR positioning further consider the following enhancements
	+ Optimization of Rel.16 measurement gap patterns
	+ Pre-configuration of multiple measurement gaps patterns and associated DL PRS configurations
	+ Introduction of DCI signaling indicating DL PRS configuration/measurement gap IDs for DL PRS transmission and processing by UE
* RAN1 send LS to RAN2/RAN4 capturing status of the RAN1 discussion related to MGs for feedback
 |
| Sony [11] | Proposal 1: Support measurement gap indication from LMF to gNB.Proposal 2: Support L1 signalling (positioning DCI) indicating the UE to perform positioning measurement.Proposal 3: Introduce a new measurement gap smaller than 20 ms in order to provide low physical layer latency. |
| LGE [13] | Proposal 1: * To reduce physical layer latency for measurement, following additional information could be considered for UE to monitor reduced the number of DL PRS:
	+ The maximum and/or the minimum number of DL PRS resource(s) or sets
	+ indices of sorted DL PPS resources and/or resource sets
 |
| Xiaomi [15] | Proposal 4: Support triggering of on-demand measurement gap by MAC CE or DCI, and the triggering of on-demand PRS and PUSCH resource allocation for PRS measurement report can be indicated by the same DCI.Proposal 6: Consider of simultaneous reception of PRS and data by different panel for MPUE by panel specific measurement gap.  |
| Lenovo, MotM [17] | Proposal 4: RAN1 to consider the benefits of lower MGRPs. Feasibility of such an enhancement to be determined by RAN4.Proposal 5: RAN1 to consider physical-layer signalling request of the MG, e.g. DCI for requesting the MG configuration.Proposal 6: gNB and LMF can align on the expected delay related to the request and application of the MG configuration in order to adapt the UE response time accordingly. May involve further work in RAN2/RAN3. |

Based on the summary, the following issues are identified.

* Preconfiguration of MG with activation/triggering
* MG request enhancements
* MG pattern enhancements
* PRS measurement enhancements inside MG

## Preconfiguration of MG with activation/triggering

Various sources (vivo [2], CATT [3], OPPO [7], InterDigital [8], Intel [9], Sony [11], Xiaomi [15], Lenovo [17]) support preconfiguration of MG with activation/triggering by lower layer signaling to reduce latency for PRS measurement inside MG.

In particular,

* vivo [2] proposed LMF-initiated pre-configuration, and activation/deactivation.
* CATT [3] proposed to support aperiodic MG
* OPPO [7] proposed to study to support lower signaling based MG configuration and request, in which single triggering can initiate multiple repetitions.
* InterDigital [8] propose MG activation with MAC CE.
* Intel [9] proposed to DCI based indication of DL PRS configuration/MG ID.
* Sony [11] proposed L1 signaling (positioning DCI) indicating the positioning measurement (in the MG).
* Xiaomi [15] proposed triggering of on-demand measurement gap by MAC CE or DCI.
* Lenovo [17] proposed DCI for requesting MG configuration. (The FL believes that this may not be a request, but rather an activation indication.)

On the other hand, Huawei [1] proposed that any enhancements with respect the MG should be discussed in the RAN4-led MG enhancement WI.

### Round 1

Based on the summary, the FL has the following tentative proposal.

### Proposal 4.1.1-1:

* Preconfiguration of multiple MGs and subsequent triggering/activation with lower layer signalings (DCI or MAC CE) are supported from RAN1 perspective.
* FFS signaling of the preconfiguration of multiple MGs
* FFS details of lower layer signaling
	+ Option 1: DCI
	+ Option 2: MAC CE
* Send an LS to RAN2 and RAN4

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| **Company** | **Yes/No** | **Comments** |
| ZTE |  | We should consult RAN4 first before we agree any enhancements related to low layer triggering MGs since this have strong impact on other transmissions. |
| vivo | Yes | To ZTEIn RAN4, pre-configured MG and activation/deactivation of an MG following a DCI or timer-based BWP switch are considered for the efficiency of RRM functionalities. So, it is logical that RAN1 identifies it first since it is beneficial for latency and the item is led by RAN1. |
| InterDigital | Yes | We support the proposal. Lower layer triggering of MG enables latency reduction. We also agree with vivo that this should be RAN1-led item. |
| CMCC | Yes |  |
| OPPO |  | Ok in principle. We are also ok with the comments from ZTE that RAN4 shall be consulted first. A LS to RAN4 is preferred. |
| Lenovo,Motorola Mobility | Yes | Support FL’s proposal of lower layer activation indication to reduce the existing RRC configuration signalling.  |
| CATT | Yes | Suggest making the change “Preconfiguration of one or more MGs…”, assume the preconfigured MG can be only one. |
| Ericsson | no | We think this has low priority for periodic PRS measurements.  |
| Qualcomm | Yes | Support. We are OK to send an LS to send that RAN1 finds this feature beneficial to be supported. |
| SONY | Yes | Support but probably too early to send LS to RAN2/RAN4 with the current progress. |
| Huawei, HiSilicon |  | We believe the proposal is generally aligned with what RAN4 is doing in Rel-17. It may be helpful if RAN4 is informed from RAN1 on another use case from positioning perspective. |
| Xiaomi | Yes  | Lower signaling for MG can reduce latency.  |
| Sumsung | Yes | But we consider this has low priority.  |

## MG request enhancements

A couple of sources (CATT [3], ZTE [4], Sony [11]) discussed different mechanism of measurement gap request.

In particular,

* CATT [3] proposed a couple of signaling options between UE, gNB, and LMF with regarding measurement gap request.
* ZTE [4] proposed LMF to request MG configuration.
* Sony [11] proposed LMF indication of MG to gNB.

### Round 1

Based on the summary, with limited input on this aspect and diversified solutions proposed by companies, it is advised for interested companies to bring this in the future meetings.

The FL has the following tentative proposal.

### Proposal 4.2.1-1:

* Further study the enhancement of measurement gap request between LMF, gNB, and UE.

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | If measurement gap request is allowed from LMF, the procedures for measurement gap request via NRPPa and configuration via RRC can be conducted in parallel with providing assistance data via LPP. This reduces latency related to measurement gap.We suggest to support measurement gap request from LMF. |
| vivo | Yes |  |
| CMCC | Yes |  |
| OPPO |  | The purpose here is to reduce the latency. LMF requesting MG would cause more latency due to the higher layer signalling, right? |
| CATT | Yes | There could be multiple options. We may decide which of them to support after the investigation. |
| Ericsson | no | Given the limited input and the broad proposal, we consider this as low priority. |
| Qualcomm | Yes |  |
| SONY | Yes |  |
| Xiaomi | Yes  |  |
| ZTE | Yes | To OPPO,Please refer to our contribution. The latency can be reduced because the procedures for measurement gap request via NRPPa and configuration via RRC can be conducted in parallel with providing assistance data via LPP. We think this should be high priority with respect to PRS measurement with MG. |

## MG pattern enhancements

A couple of sources (Sony [11], Lenovo [17]) proposed to add new MG patterns e.g. lower MGRP, to reduce the measurement latency. Due to limited input and the nature of cross-WG work, it is advised to further study the gap pattern enhancements in the future meeting or propose the enhancements in RAN4 directly.

### Round 1

The FL has the following tentative proposal.

### Proposal 4.3.1-1:

* Further study whether the MG pattern can be enhanced.

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | This is should be discussed by RAN4. |
| vivo |  | If the MG pattern is the detailed content or the enhancement of preconfiguration MGs, we can agree with it. |
| CMCC | Yes |  |
| OPPO | Yes |  |
| Lenovo,Motorola Mobility | Yes | Agree that RAN4 has to make the final decision on this aspect.  |
| CATT |  | Our preference is to let RAN4 to handle this.  |
| Ericsson | no | We should leave the issue to RAN4. |
| Qualcomm |  | OK to leave it up to RAN4 |
| SONY | No | RAN4 issue. |

## PRS measurement enhancements inside MG

A couple of sources (vivo [2], Qualcomm [6], Interdigital [8], LGE [13], Xiaomi[15], Lenovo [17]) proposed PRS measurement enhancements inside the MG.

In particular,

* vivo [2] proposed to support concurrent processing of multiple positioning frequency layers inside MG.
* Intel [9] proposed to support simultaneous PRS processing across multiple positioning frequency layers
	+ Note: the proposal of [9] does not explicitly mention whether the measurement is inside MG or not
* Qualcomm [6] proposed to discuss priority between PRS and other RRM measurement and introduce positioning-only MGs. In addition, Qualcomm [6] proposed to split MGL into “Measurement Time” and “Processing Time”, and SRS can be transmitted in “Processing Time” of the MG.
* InterDigital [8] proposed to support priority indication of measurement gap for PRS.
* LGE [13] proposed to optimize the PRS configuration for the measurement inside a gap.
* Xiaomi [15] proposed to simultaneous reception of PRS and data by different panels by panel specific MG.
* Lenovo [18] proposed for gNB and LMF to align on the expected delay of MG request/application to adapt a proper UE response time.

### Round 1

Based on the summary, it is difficult to find any convergence on the measurement enhancement inside the gap. Interested companies are advised to bring this in the future meetings.

The FL has the following tentative proposal.

### Proposal 4.4.1-1:

* Further study the measurement enhancements inside MG.
	+ Concurrent processing of PRS in multiple positioning frequency layers
	+ Priority between PRS and other RRM
	+ MG configuration dedicated for PRS measurement and “measurement time” and “processing time” in the MG
	+ Priority indication of measurement gap for PRS
	+ Proper configuration of PRS resource (set) number and sorting
	+ Panel-specific MG to allow data and PRS received simultaneously via different panels
	+ gNB and LMF to align on the expected delay of MG request/application to adapt a proper UE response time

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| InterDigital | Yes | We support the proposal. |
| Ericsson | yes | OK to discuss the scope further to narrow down the possible enhancements.  |
| Qualcomm | Yes |  |
| SONY | Yes | OK to study further. |
| Xiaomi | Yes  | Ok to study further |
| ZTE | No | The scope is too broad. We don’t need to have a agreement in this meeting. Interested companies can bring their further analysis in next meeting. |
| LG | Yes |  |

# Others

## Summary of views based on t-doc submission

The section lists the proposed enhancements that do not fall into the above categories.

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| CMCC [5] | Proposal 5: Support enhancing the DL PRS pattern to be partial/non-staggered, e.g., support 1 symbol DL PRS with comb 2, 4, 6, 12. |
| Nokia, NSB [14] | Proposal 2: 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.Proposal 5: 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. |
| Xiaomi [15] | Proposal 8: To indicate the first arrival path by reporting the arrival time of each beam in beam measurement report. |
| Ericsson [18] | Proposal 4 Do not support lower PRS periodicities for DL PRS in rel17. a. Note: periodicity of measurement reporting is a separate discussion |

Interested companies are advised to provide input whether these issues listed above should be discussed in this meeting, or further studied in future meetings.

### Views collection

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| --- | --- |
| **Company** | **Comments** |
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# Summary

TBD