**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.

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| **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:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2104643.zip) Draft reply LS to SA2 on Scheduling Location in Advance Qualcomm Incorporated * [R1-2105937](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2105937.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.

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| **Company** | **Yes/No** | **Comments** |
| ZTE | Agree |  |
| vivo | Yes |  |
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# 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.

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| **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 occasion  Proposal 2-2: Aperiodic PRS transmission may be confined to the scenario that the transmission being from the serving gNB and the corresponding TRPs  Proposal 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 < MGRP  Proposal 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” here  If 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. | |
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## 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 |  |
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## 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)

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| **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. |

## 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. |
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### 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.

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| **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 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]   + 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 follows Proposal 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 |
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## 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.

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| **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. |
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## 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.

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| **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. |
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## 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.

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| **Company** | **Yes/No** | **Comments** |
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## 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.

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| **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. |

## 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

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| --- | --- | --- |
| **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. |

### 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. |

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| --- | --- | --- |
| **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? |

## 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

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| --- | --- | --- |
| **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 |  |
|  |  |  |

## 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 |  |
|  |  |  |

## 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 ZTE  In 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. |

## 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 |  |
|  |  |  |

## 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. |
|  |  |  |

## 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

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| InterDigital | Yes | We support the proposal. |
|  |  |  |
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# 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