**3GPP TSG RAN WG1 #105-e  R1-2105991**

**e-Meeting, May 10th – May 27th, 2021**

**Agenda Item: 8.5.4**

**Source: Moderator (Huawei)**

**Title: FL summary #3 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.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 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 (closed)

**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 |  |
| Nokia/NSB | Yes |  |

**FL summary:**

No action needed. The discussion is closed.

# 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 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.

|  |  |  |
| --- | --- | --- |
| **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. | |
| 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 8.5.1  2, 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. |
| Nokia/NSB | In principle | The main bullet should probably be finally decided in RAN4 so we may need to reformulate a bit (e.g., single sample processing is beneficial from RAN1 point of view). The FFS on Relation with (N,T) is a bit unclear to us. Could FL explain the intention? |
| Intel | YES | Instead of single sample, we prefer to use a single period (or occasion) term. |
| FL |  | To Nokia,  The FFS from the proposal submitted by QC   |  | | --- | | 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 |   To my knowledge, the intention here perhaps could be that “when single PRS processing is adopted, a refined PRS processing model could be considered”. For example, the processing time may be shorter than the value by setting the N\_sample = 1 in the current RAN4 defined requirement.  To Intel,  I think “sample” was used in RAN4 spec, and widely referred in the submitted t-doc. One issue regarding the period is what “period” is defined when multiple periodicities could be possible on the positioning frequency layer. |
| vivo |  | Agree with FL that Single sample PRS processing should be mapped to RAN1 definition, in our view, the periodicity is defined as a set level in RAN1. So we propose   * Single-sample measurements correspond to measurements performed within a single instance of the DL-PRS Resource Set subject to UE capability is supported from RAN1 perspective. |

**FL summary:**

Among the companies providing the reponse

* Support (11): ZTE, vivo, Lenovo, MTK, Ericsson, Qualcomm, Huawei, Xiaomi, LG, Nokia, Intel
* Not support (3): CMCC, OPPO, CATT

Those companies suggesting no to support this argue that this discussion may be interacting with the enhancements discussed in 8.5.1. However, the proponents already clarified that this can be discussed separately, and may perhaps facilitate the discussion in 8.5.1.

For the supporting companies, wording change is also suggested, arguing that this should be better decided by RAN4 and the impact on related performance requirement should also be considered by RAN4.

### Round 2

Based on the discussion of the GTW session. The proposal 2.1.2-1 is updated below. Companies are encouraged to check the wording.

**Proposal 2.1.2-1 (rev1):**

* Single-sample PRS processing subject to UE capability is supported from RAN1 perspective.
  + Send an LS to RAN4 informing that
    - Single-sample measurements corresponding to measurements performed within a single instance of the DL PRS resource set on a PRS resource are beneficial for reduction of measurement latency from RAN1 point of view.
    - RAN4 is requested to check the feasibility of measurements performed within a single instance of the DL PRS resource set and identify the impact on requirements/side condition.
  + RAN1 to further study the following aspects
    - Details of UE capability
    - Signaling details, e.g., to indicate whether measurement is based on one or more samples
    - Whether the PRS sample processing time is defined and the relation with (N, T).

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | We prefer to keep it more general to cover multiple samples less than 4.   * Multiple-samples (<4) PRS processing subject to UE capability is supported from RAN1 perspective.   + Send an LS to RAN4 informing that     - Multiple-samples (<4) measurements corresponding to measurements performed within multiple instances (<4) of the DL PRS resource set on a PRS resource are beneficial for reduction of measurement latency from RAN1 point of view.     - RAN4 is requested to check the feasibility of measurements performed within a single instance of the DL PRS resource set and identify the impact on requirements/side condition.   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. |
| OPPO |  | We do not think we can agree single-sample PRS processing is supported now before the RAN4 confirm it is feasible to do that.   * ~~Single-sample PRS processing subject to UE capability is supported from RAN1 perspective.~~   + Send an LS to RAN4 informing that     - Single-sample measurements corresponding to measurements performed within a single instance of the DL PRS resource set on a PRS resource are beneficial for reduction of measurement latency from RAN1 point of view.     - RAN4 is requested to check the feasibility of measurements performed within a single instance of the DL PRS resource set and identify the impact on requirements/side condition. |
| Xiaomi |  | We share same view as OPPO. If we agree to support it before the check of RAN4, what shall we do if RAN4 feedback that there are some problems on feasibility and impacts on requirements/side condition? |
| vivo |  | Sorry with the mistake that I didn’t express our view correctly.  We prefer to keep the main bullet and first sub-bullet, and modify as following   * ~~Single-sample PRS processing~~ Single-sample measurements corresponding to measurements performed within a single instance of the DL PRS resource set on a PRS resource subject to UE capability is supported from RAN1 perspective.   + Send an LS to RAN4 informing that     - Single-sample measurements corresponding to measurements performed within a single instance of the DL PRS resource set on a PRS resource are beneficial for reduction of measurement latency from RAN1 point of view.     - RAN4 is requested to check the feasibility of measurements performed within a single instance of the DL PRS resource set and identify the impact on requirements/side condition.   And we would like to clarify that the main bullet is from RAN1 perspective. If RAN4 later think single sample measurement is not feasible, RAN1 can revisit this agreement.  ~~We are OK with the modification from OPPO~~  We would like to noted that the description “a single instance of the DL PRS resource set” is used in TS 38.214  *-dl-PRS-ResourceTimeGap* defines the offset in number of slots between two repeated instances of a DL PRS resource with the same *nr-DL-PRS-ResourceSetId* within a single instance of the DL PRS resource set. |
| CATT |  | Fine with OPPO’s revision. |
| Nokia/NSB |  | As commented online we also have an issue with directly agreeing to this feature without asking RAN4 first. How can we know that the accuracy wont be negatively impacted? In our view the latency gains are only worthwhile if the accuracy is not lowered by doing so. The version from OPPO seems okay in principle.  In addition, in the second main bullet we feel that there should be more clarification that this is related to single-sample measurements. For the third sub-bullet on processing time should mention that this may have RAN4 dependency. |
| Lenovo,Motorola Mobility | Yes | Support FL’s proposal. |
| LG |  | Agree with OPPO’s proposal |
| Ericsson | Yes | Similar to what ZTE suggested, we can agree that PRS processing on N<4 samples is supported in RAN1, and let RAN4 evaluate and let RAN4 check the feasibility. The value of N can be decided based on RAN4 feasibility check. |
| Qualcomm | Yes (OK with the medication of <4 also) | To OPPO/Nokia/LG: Why it will not be feasible? RAN4 would just have to adjust side conditions, but why it would not be feasible? Arent we doing single-shot CSIRS measurements? Do you think any feasibility problem if the SINR is 30 dB? For sure not. RAN4 will just do some more simulations, a year from now likely, and derive some side conditions. I don’t see why we have to wait until then.  Accuracy may be impacted, but that’s fine, its part of the tradeoff. Does that make it less feasible?  RAN1 agrees on single sample measurements and RAN4 adjusts the side conditions/accuracy targets. |
| CMCC | Yes | We support this proposal as it is straightforward to reduce the positioning latency from RAN1 perspective. Whether it is feasible will be further checked by RAN4. |

**FL summary**

Based on the input so far, three companies suggest to remove the wording that “the feature is supported from RAN1 perspective”, because they fear that the accuracy performance may be impacted, while majority of other companies seem supportive on this aspect by adding more candidate values instead of limiting to single sample.

To the understanding of the FL, the side condition for allowing processing with lower sample numbers can be discussed by RAN4, and network should have the ability to switch from lower sample numbers to 4 if the condition is not suited for single sample.

### Round 3 (closed)

The FL has the following proposal update for Round 3.

**Proposal 2.1.3-1**

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE | Support. |  |
| Sony | Support | We suggest to slightly revise this sentence. So that: “RAN1 to further study at least the following aspects for allowing multiple-sample PRS processing” |
| Ericsson | Yes | Support |
| vivo |  | We are not sure only supporting“Multiple-sample (<4) measurements”（for example： 2 sample）can satisfy R17 latency requirement.  In our view, as long as the sample number exceeds 1 measurement, the 10ms physical layer latency cannot be satisfied.  So, we prefer to keep the description of single sample, and suggest the description consistent in main bullet and sub-bullet in the LS-bullet. Proposal 2.1.3-1  * Multiple-sample (<4) and single-sample processing corresponding to measurements performed within multiple instances (<4) and single-sample of the DL PRS resource set on a PRS resource subject to UE capability is supported from RAN1 perspective.   + Send an LS to RAN4 informing that     - Multiple-sample (<4) and single-sample measurements corresponding to measurements performed within multiple instances (<4) and single-sample of the DL PRS resource set on a PRS resource are beneficial for reduction of measurement latency from RAN1 point of view.     - RAN4 is requested to check the feasibility of measurements performed within a single instance of the DL PRS resource set and identify the impact on requirements/side condition. |
| CATT | Support |  |
| Intel | YES |  |
| Nokia/NSB |  | In our understanding if the accuracy is degraded by reducing the number of samples then it may not be worthwhile to support this feature. We are not saying that it is not feasible, but we understand that low latency is needed along with high accuracy. So, if we reduce the latency by going for single-sample measurements that is only good if the accuracy is still high. For example, if we need 4 samples to achieve the QoS accuracy then we don’t actually gain anything in latency. We think that it is up to RAN4 to tell RAN1 if the accuracy is degraded and if so by how much. If they reply that the accuracy is the same (or close) then we are happy to support this feature. |

**FL summary**

Based on the feedback, vivo suggested to add single-sample back considering multi-sample precludes the case of single sample. The FL thinks that it should be useful to add single sample back. Vivo also suggested to align the text with content of the proposed RAN4 LS. Nokia still think that the main bullet should be removed, as whether the feature can be supported should be confirmed by RAN4. However, there is a strong request to make progress on RAN1 part so that further RAN1 work can be carried out based on the main bullet, and companies believes that RAN4 has the freedom to adjust the side conditions.

Thus, the FL updated the proposal as follows for GTW session.

**Proposal 2.1.3-2**

* M-sample (1<=M<4) PRS processing corresponding to measurements performed within M instances of the DL PRS resource set on a PRS resource subject to UE capability is supported from RAN1 perspective.
  + Note: The target accuracy requirement of Rel-17 positioning should still be met.
  + Send an LS to RAN4 informing that
    - M-sample (1<=M<4) measurements corresponding to measurements performed within M (1<=M<4) instances of the DL PRS resource set on a PRS resource are beneficial for reduction of measurement latency from RAN1 point of view.
    - RAN4 is requested to check the feasibility of measurements performed within M (1<=M<4) instances of the DL PRS resource set and identify the impact on requirements/side condition.
  + RAN1 to further study at least the following aspects for allowing M-sample (1<=M<4) PRS processing
    - Details of UE capability
    - Signaling details, e.g., to indicate whether measurement is based on one or more samples
    - Whether the PRS sample processing time is defined and the relation with (N, T).
      * Note: This may have RAN4 dependency

### After GTW

The following agreements are made.

Agreement:

M-sample (1<=M<4) PRS processing corresponding to measurements performed within M instances of the DL PRS resource set on a PRS resource, subject to UE capability, is beneficial from a RAN1 perspective for latency reduction.

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

## 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.

|  |  |  |
| --- | --- | --- |
| **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 |  |
| Nokia/NSB | No | Not sure that this is a RAN1 decision to make. Most we could say is that reducing location response time is beneficial and send LS to RAN2. The FFS points are a bit vague to us so may not be needed unless more clearly explained. |
| Intel |  | We need to discuss first the definition of the location response time including components and the relevance to the PHY layer discussion |
| FL |  | To Nokia:  The second FFS comes from Lenovo’s proposal. To my understanding, when the response time is provided in a finer granularity, LMF should have a better knowledge on the delay components between LMF transmitting LPP RequestLocationInformation and receiving LPP ProvideLocationInformation, so that a proper response time is set and UE will not have to deal with the case that the response time is not sufficient for PRS processing.  The third FFS comes from the proposal from ZTE. I put it under response time because early fix response time may also be enhanced, and whether or not new UE behavior for the early fix response will be defined can be studied further. |

**FL summary:**

Among the companies providing the reponse

* Support (9): ZTE, vivo, OPPO, Lenovo, CATT, Qualcomm, Huawei, Xiaomi, LG
* Not support (4): CMCC, Ericsson, Nokia, Intel
* Unclear (1): Samsung

Most companies proposing not to support this functionality believes that this can be rather RAN2 work. In addition, one source concerned the components in the location response time and the relationship with physical layer latency analysis.

The supporting companies also provided revision to ease the concern from the opponents.

### Round 2

Taking all the comments into account, the FL has the following update proposal.

**Proposal 2.2.2-1:**

* Send an LS to RAN2 informing that
  + From RAN1 perspecitive, it is beneficial to support a finer granularity for location response time in order to reduce latency. The details can be up to RAN2.
* RAN1 to further study the following aspects
  + Mechanisms to adapt the UE response time
  + Whether and how early fix report is enhanced.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE | Yes | Some small revisions.   * Send an LS to RAN2 informing that   + From RAN1 perspecitive, it is beneficial to support a finer granularity for location response time in order to reduce positioning latency. The details can be up to RAN2.   FL comment: Added. |
| OPPO |  | Since we say that the deails can be up to RAN2, why do we need the 2nd bullet. Suggest to remove it.   * Send an LS to RAN2 informing that   + From RAN1 perspecitive, it is beneficial to support a finer granularity for location response time. The details can be up to RAN2. * ~~RAN1 to further study the following aspects~~   + ~~Mechanisms to adapt the UE response time~~   + ~~Whether and how early fix report is enhanced.~~ |
| Xiaomi | Yes |  |
| Vivo | Yes |  |
| CATT | Yes | A question for clarification: should the “early fix report” be counted as one of the mechanisms to adapt the UE response time? |
| Nokia/NSB |  | In our understanding it is not only details that are up to RAN2 but also if the change should be made is up to RAN2. Suggest to change the wording to reflect that. |
| Lenovo,Motorola Mobility | Yes | Support |
| LG | Yes | Agree |
| Ericsson |  | We have similar view as Nokia. |
| CMCC | Yes |  |

**FL summary**

Among the companies providing inputs, three companies provided modification suggestions.

* OPPO think that the second main bullet should be removed given that RAN1 already hands the details to RAN2.
* Nokia and Ericsson think that instead of the details up to RAN2, but whether the change can be made is also up to RAN2.

To the understanding of the FL, it should be OK to let RAN2 to consider the spec impact and RAN1 identifies the benefit and informs RAN2 of it.

### Round 3

The FL has the following proposal update for Round 3.

### Proposal 2.2.3-1:

* Send an LS to RAN2 informing that
  + From RAN1 perspective, it is beneficial to support a finer granularity for location response time in order to reduce latency.
  + RAN2 is requested to check if it can be supported and design the signaling details if supported.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | We prefer to keep the following part in round 2,   * RAN1 to further study the following aspects   + Mechanisms to adapt the UE response time   + Whether and how early fix report is enhanced.   From our understanding, we may need to design new UE capabilities to facilitate measurement report with the finer granularity. Even whether the feature would be supported or not can be decided by RAN2, there is no harm for RAN1 to further study the potential spec impact. |
| Sony |  | We still consider this is beyond RAN1 scope. |
| vivo | Yes |  |
| CATT | Yes | We are also fine to let RAN2 to work this out. |
| Sony |  | We still consider this is beyond RAN1 scope. |
| Lenovo,Motorola Mobility | Yes | Fine to send an LS to RAN2, but not sure if RAN1 has to confirm if any potentially new agreed response time values can be supported, e.g. 100, 200 ms, etc. |
| CMCC | Yes |  |

## 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. |
| Nokia/NSB | Support in principle |  |
| Intel | NO | Proposal is too general for RAN1 discussion, which should be focused on the physical layer aspects |

**FL summary:**

Among the companies providing the reponse

* Support (10): vivo, InterDigital, CMCC, Lenovo, CATT, SONY, Xiaomi, Samsung, LG, Nokia
* Not support (6): ZTE, OPPO, Ericsson, Qualcomm, Huawei, Intel
* Unclear (1): MTK

Companies not supporting this feature argued that this may not be within the RAN1 scope.

The benefit seems quite clear from the comments provided by the proponents.

This enhancement could be part of the objective led by RAN2, but RAN1 is also in the supporting WG of this objective.

### Round 2

Taking all the comments into account, the FL has the following update proposal.

**Proposal 2.3.2-1:**

* With regard to the enhancement on PUSCH scheduling to carry the LPP measurement report, consider one of the following alternatives
  + Alt.1 The enhanment is supported from RAN1 perspective
    - 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)
  + Alt.2 Support of the enhancement is up to RAN2

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE | Alt.2 | It’s out of RAN1 scope. |
| OPPO | No | Do not think we need this proposal.  In Physical layer, we do not design or grant PUSCH for one paritular RAN-application layer applications. In RAN1, we support dynamic PUSCH and/or configured grant. The gNB can configure the PUSCH accordingly for service requirement by system implementation and scheduling. Do not see why we need design PUSCH for positioning. UE can transmit all kinds of traffic through PUSCH and we do not have application traffic-specific PUSCH design.  Re Alt.2: RAN2 can dicuss if they do some enhancement. We RAN1 should not make decision for RAN2. |
| Xiaomi | Yes | Prefer Alt 1 |
| CATT | Yes | Support Alt.1. Need to discuss the PHY support to prioritize the PUSCH scheduling for positioning report for meeting R17 target latency requirement. |
| InterDigital | Yes | We support Alt. 1 |
| Nokia/NSB | Support in principle |  |
| Lenovo,Motorola Mobility | Yes | Support Alt.1 of FL’s proposal. |
| LG | Yes | We are supportive of FL’s proposal. |
| Ericsson | Alt2 | It is out of RAN1 scope. |
| Qualcomm |  | We think it is within RAN2 scope |
|  |  |  |

**FL summary**

There is a majority support of the proposal, while some opposing companies think this should be RAN2 to discuss (Alt.2).

To the understanding of the FL, it should be beneficial to list the alternatives so that companies can evaluate and understand the pros and cons of either alternatives.

### Round 3 (closed)

The FL has the following proposal update for Round 3.

**Proposal 2.3.3-1:**

* With regard to the enhancement on PUSCH scheduling to carry the LPP measurement report, consider one of the following alternatives
  + Alt.1 The enhancement is supported from RAN1 perspective
    - 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)
  + Alt.2 Whether or not to support of the enhancement is up to RAN2

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE | Alt.2 |  |
| Sony | Support | We prefer Alt.1 |
| Ericsson | No | Since this is out of RAN1 scope, we do not need to discuss this proposal. RAN1 cannot make a decision on supporting this enhancement (as proposed in Alt 1). |
| vivo | Yes |  |
| CATT | Yes | To Ericsson: In our view, there is a need for RAN1 and RAN2 to work together on the enhancement on PUSCH scheduling for reducing the latency. |
| InterDigital | Yes | We prefer Alt. 1 |
| Intel | NO | Given, that it is not related to the physical layer signaling, we think that RAN2 can directly discuss it. |
| Qualcomm | Alt. 2 |  |

**FL summary**

It looks like some companies are not willing to list the options. From FL’s point of view, it is better for interested companies to further discuss this issue in the next meeting, aiming to address the concern, including but not limited to

* Work split between RAN1 and RAN2/RAN3 to enable the feature, targeting explaining the RAN1 spec impact to support this procedure.
* Why the service provided by physical layer should target this particular usage.

## 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.

|  |  |  |
| --- | --- | --- |
| **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. |
| Huawei, 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. |
| Nokia/NSB | No | It is out of scope. This is a plenary level decision. RAN1 recommend this item for study and it was not included in the WID objectives. |
| Intel | Comments | We need to focus on the solution to reduce latency and NR PRS overhead.  Signaling mechanism to trigger DL PRS transmission/UE measurements seems required to achieve these goals. Whether it is called AP/SP PRS is not so important at this stage of discussion. |

**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 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 |
| 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. |
| Nokia/NSB | Yes | Any solution which targets latency reduction related to the request and response of location measurements or location estimate is in scope in our view. Not sure that we need to discuss a high level statement such as this. Clearly the WID does not say explicitly we will specify low layer support for measurements or reports. |
| Intel | Comments | In our view before discussion on this aspect, we need to conclude on potential signaling to trigger UE DL PRS measurements and DL PRS transmissions |

**FL summary:**

Among the companies providing the reponse for AP/SP PRS

* Within the scope (6): InterDigital, CMCC, CATT, SONY, Xiaomi, LG
* Not within the scope (6): ZTE, OPPO, Ericsson, Qualcomm, Huawei, Nokia
* Unclear (1): Intel

Among the companies providing the reponse for measurement request and response in lower layers

* Within the scope (7): vivo, CMCC, CATT, SONY, Xiaomi, LG, Nokia
* Not within the scope (7): ZTE, OPPO, MTK, Ericsson, Qualcomm, Huawei, Samsung
* Unclear (1): Intel

### Round 2

Taking all the comments into account, the FL has the following update proposal.

**Proposal 2.4.2-1:**

* RAN1 confirms support of AP/SP PRS is NOT in the WID of Rel-17 positioning for latency reduction.

**Proposal 2.4.2-2:**

* RAN1 confirms support of measurement request and report in lower layers is NOT in the WID of Rel-17 positioning for latency reduction.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | Revised Proposal 2.4.2-1 as following since some companies also propose this in on-demand PRS.  RAN1 confirms support of AP/SP PRS is NOT in the WID of Rel-17 positioning for latency reduction.  OK with Proposal 2.4.2-2.  FL comment: fixed as suggested. |
| OPPO | Yes | Ok to 2.4.2-1 and 2.4.2-2 |
| Xiaomi |  | We want to clarify that is issue 2.3 about the measurement report in lower layers?  FL comments: issue 2.3 is targeting reporting in higher layers, i.e. LPP. The LPP message needs to be carried over a PUSCH anyway. |
| Vivo | Proposal 2.4.2-1 Yes  Proposal 2.4.2-2 No | 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) is what RAN1 recommended for normative work based on our hard work on latency evaluation.  Although the specific wording (e.g., via RRC signaling, MAC-CE and/or physical layer procedure, and/or priority rules) in the brackets is deleted, it does not mean that we have deleted this item in WID. It is observed that all description in the bracket are deleted regarding different items. |
| CATT |  | Proposal 2.4.2-1:  We share the similar view as Intel’s comment in Round 1. Signaling mechanism to trigger DL PRS transmission/UE measurements should not be excluded from WID. Thus, we suggest making it clear that here is that AP/SPS PRS triggered by lower layer command (DCI/MAC CE) is not in the WID scope.   * RAN1 confirms support of AP/SP PRS triggered by lower layer signalling is NOT in the WID of Rel-17 positioning for latency reduction.   FL comments: I think it was already defined in the SI that AP-PRS is triggered by DCI and SP-PRS is triggered by MAC CE. Not sure there is any room to change the AP/SP PRS triggering mechanism. On other hand, for periodic PRS with single shot measurement at UE or even triggered measurement can be discussed, but I prefer not to call it AP/SP PRS, which only causes confusion.  Proposal 2.4.2-2:  We share the similar view as vivo. For example, DL PRS may be transmitted periodically, while the UE measurement can be triggered by lower layer signaling to reduce the latency if the UE already has the PRS assistance information. |
| InterDigital | No for Proposal 2.4.2-1 | PRS types (e.g., aperiodic/semi-persistent) that can be dynamically triggered reduces latency in positioning. |
| Nokia/NSB | Support proposal 2.4.2-1 |  |
| Lenovo,Motorola Mobility | Yes | Support both proposals |
| LG |  |  |
| Ericsson |  | ok to capture the following proposals as conclusions in the RAN1 chairman’s notes. Proposal 2.4.2-1:  * RAN1 confirms support of AP/SP PRS is NOT in the WID of Rel-17 positioning for latency reduction.  Proposal 2.4.2-2:  * RAN1 confirms support of measurement request and report in lower layers is NOT in the WID of Rel-17 positioning for latency reduction. |
| CMCC |  | For Proposal 2.4.2-1, as per FL’s response, AP-PRS is triggered by DCI and SP-PRS is triggered by MAC CE, then are we precluding the case that using PHY layer signaling (e.g., using MAC-CE or DCI) to trigger/stop on-demand PRS?  FL: I think the triggering of measurement using MAC/PHY can be discussed. Note that even the MAC/PHY based reporting resource is discussed under 2.3. For on-demand PRS, I think this is related to how the “demand” is sent to the network, whether we can have MAC/PHY layer-based request can be discussed in on-demand PRS. |

**FL summary**

Among the companies providing input to this subject, there seems a majority support of confirming that AP/SP PRS is not in the WID scope. CATT mentioned that the triggering mechanism can be updated, while InterDigital think that the support of AP/SP PRS is justified for reduction.

To the understanding of the FL, the latency reduction from AP/SP PRS is acknowledged in the SI, but whether this should be only from the serving cell or can also be from the non-serving cell was a bit controversy, which later was concluded as “study if needed specify” category in the TR. Later in RAN#91-e, there was discussion whether to include this in the WID, but companies seemed to agree not to include those down-prioritized items in the WID.

Among the companies providing input to this subject, there seems a different understanding whether measurement request and report procedure in lower layers is in the WID.

To the understanding of the FL, it is not clear how this can work without changing the architecture, e.g. how gNB should be aware of the PRS configuration, the required measurement, etc. Since RAN2 is leading this objective, and whether/how the procedure can be supported should be better checked by RAN2.

### Round 3

The FL has the following proposal update for Round 3.

### Proposal 2.4.3-1:

* RAN1 confirms support of AP/SP PRS is NOT in the WID of Rel-17 positioning for latency reduction.

### Proposal 2.4.3-2:

* RAN1 does not plan to discuss support of measurement request and report in lower layers for latency reduction unless the feature can be confirmed by RAN2.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE | Okay with both proposals. |  |
| Sony | Proposal 2.4.2-1 Yes  Proposal 2.4.2-2 No | 2.4.2-1 can be discussed in “on-demand PRS”  2.4.2-2 it is unclear how to get the RAN2 confirmation.  FL: I am assuming interested companies can contribute this in RAN2 (since it is RAN2-led objective, I believe), and send an LS to RAN1 to trigger the related work in RAN1.  Thanks for the comments, we agree. |
| Ericsson |  | We are ok with Proposal 2.4.3-1. But this should be already clear from the ePos WID.  For Proposal 2.4.3-2, ok. But we can make it a conclusion. |
| Vivo | Proposal 2.4.3-1 Yes  Proposal 2.4.3-2 No | Regarding measurement request and report in lower layer, we cannot understand why we exclude it in the first WID meeting given the latency benefit is shown in our contribution and SID evaluation. At least, we think the physical layer latency is defined by RAN1, and it is our work to identify whether it is benefit on latency reduction and inform to other groups. |
| CATT | Proposal 2.4.3-1 Yes  Proposal 2.4.3-2 No | We share the similar view as vivo. As we commented previously, using lower layer signaling to trigger UE measurement report is useful for reducing the latency. |
| InterDigital | Proposal 2.4.3-1 Yes |  |
| Nokia/NSB |  | Agree with Ericsson on Proposal 2.4.3-1. This should be clear from the WID and it is not RAN1’s job to rewrite the WID so we are not sure anything needs to be agreed.  For proposal 2.4.3-2, is the intention to send an LS to RAN2? We don’t think we really need to agree or conclude on anything which we “won’t discuss”. We can just simply deprioritize the topic in future discussions unless something changes in other WGs. |
| ZTE |  | We think simply make two proposal as conclusions. |
| Lenovo,Motorola Mobility | Proposal 2.4.3-1 Ok | On P2.4.3-1 seems to be under the scope of the on-demand PRS discussion, while P2.4.3-2 is subject to a change in the LCS architecture which has not supported in Rel-17. |
| CMCC | Yes for both | Thanks for the clarification from FL, and we are OK with both Proposals. |

## 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 (closed)

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. |
| Nokia/NSB | No | Could the FL highlight the proposal from our Tdoc, [14], which they say we are proposing PRS processing priority? We only propose to work on new priority rules for SRS in our TDoc. |
| Intel | OK | OK to further study |
| FL |  | To Nokia,  The proposal is based on the text preceeding proposal 4 in Nokia’s contribution.   |  | | --- | | The network should be at least aware of this variability when deciding the TRP list for the respective UE. |   And as the result, “Option 3: LMF may configure a subset of TRPs from the assistance data for measurement” was added. If the intention is not aligned with Nokia’s understanding, I will remove Nokia from the supporting companies and Option 3. |

**FL summary:**

Among the companies providing the reponse

* Support (7): ZTE, Lenovo, Qualcomm, Huawei, ZTE, LGE, Intel
* Not support (7): vivo, CMCC, OPPO, CATT, Ericsson, Xiaomi, Nokia

There is no majority support on the study. Given that the proposal is “FFS” in nature, there is no need to further discuss it this meeting. Interested companies are encouraged to bring their contribution in the next RAN1 meeting to justify the necessity to define the priority among PRS.

## 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 (closed)

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 QC  At 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. |
| Nokia/NSB | No | Not clear what the proposal is. Is this related to the disacussion in 8.5.1 or the SA2 LS or something else? |
| Intel | OK | OK to further study |

**FL summary:**

There is no majority support on the study. Given that the proposal is “FFS” in nature, there is no need to further discuss it this meeting. Interested companies are encouraged to bring their contribution in the next RAN1 meeting to justify the necessity to define PRS measurement window configuration with joint consideration of other agendas.

## 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 |  |
| Nokia/NSB | Support |  |
| Intel | OK |  |

**FL summary:**

It seems all companies expressed support for the proposal. Although the proposal is “FFS” in nature, it is recommended to be captured in the notes.

### Round 2

Normally we do not have to agee to any “study issue” in the WI phase. Companies are encourage to provide views on whether proposal 2.7.1-1 should be treated in the GTW if time allows given that there is unanimous support for further study.

### Discussion point (Input requested)

* Is there any need to treat proposal 2.7.1-1 in the GTW if time allows?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| MTK | Yes | We are okay for this |
| Lenovo,Motorola Mobility | Yes | Support |
| vivo | No | We can directly discuss the set of (N,T) or sending LS to RAN4 about this issue in the next meeting |
| Intel | No | We are OK with the study. |
| ZTE | Yes | Instead of agreeing a “study issue”, we can try to change the wordings as below,  Support a new set of (N,T) by UE for the purpose of latency reduction  FFS: values of (N,T)  FFS: details of signaling |

## 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 BWP  Therefore, 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 |  |
| Nokia/NSB |  | Is the intention to support this feature for within the active BWP or also outside the active BWP? |
| Intel |  | We do not fully understand the proposal, we need to clarify what “outside of MGs” means  Our understanding is that this is a mode of UE operation (DL PRS measurement) when measurement gap is not configured to UE. It has certain implications at the UE and gNB side that need to be clarified first, including:   * Mechanism to trigger UE DL PRS measurements and report * Bandwidth/numerology relationship and potential switching from(to) active DL BWP to(from) DL PRS bandwidth * UE/gNB assumptions on processing of DL PRS and other DL physical channels / signals * Potential restrictions on gNB behavior * UE DLPRS processing capabilities * Consider valid deployment scenarios:   + Single gNB with multiple TRPs   + Serving gNB and multiple neighbor gNBs   If reasonable options have been found, then we are OK to support that enhancement. |
| Qualcomm |  | Reply to Huawei:  Thanks for the reply. This is what we are worried actually:That this enhancement narrowly says to remove the MG, so that we think that latency is reduced, but then what? How will this feature work from end to end, and will it really be lower-latency than an MG-based solution?   * The gNB would have to know which BWP should be active. Even in scenarios that there is a single BWP in a CC, who said it is going to be wide enough to measure PRS, and result into a low-latency/high-accuracy solution? * Somehow the gNB should know which BWP to be used. Having a feature that opportunistically works, and in other cases do not work, should be a low priority, unless we clearly understand how it is supposed to work in the majority of cases.   We are within the scope of low latency Positioning. This means that there needs to be clean opportunities and rules for a UE to quickly measure the required PRS. If removing the MG for the purpose of reducing the latency, would also mean that the UE will not have a measurement/processing window where PRS masurement/processing is prioritized, i don’t see any latency reduction.   * The UE will be advertising 10 times higher latencies for MG-less PRS compared to MG-based PRS, if it doesn’t have clean measurement/processing opportunities; * It will turn out that the MG-based PRS will be the low latency feature, and the MG-less PRS was done for other (?) purposes.   In other words for MG-less PRS to be a feasible end-to-end ***low-latency/high-accuracy*** solution (equal or better latency to a low-latency/enhanced MG-based PRS approach) we consider at least the following aspects essential to be understood by the group:   * gNB needs to be aware of the required-BWP-characteristics / BWP / PRS-to-be-measured, and needs to learn this in a way that does not increase the latency significantly. * Even in the case that by-luck / opportunistically the Active BWP is the one that is good for Positioning also (not sure why would an LMF consider this a viable positioning feature, unless the thinking is an out-of-spec LMF-to-serving-gNB coordination), PRS measurement/processing prioritization over all other DL signals/channels/procedures for a UE-capability-reported period of time is really essential to get low latency.   + If this is not agreed, then what low-latency are we talking about? It will be lower latency to do MG-based processing, which already supports a per-UE MG-based PRS.   In other words, the same UE that will be doing MG-less PRS, will be able to do ***faster*** processing if an MG is configured. So, the MG-based PRS will be a lower-latency feature, assuming that we just enhance the MG-based request/trigerring. |
| FL |  | To Nokia, currently the proposal does not preclude either case, which can be subject to further study.  To Intel  The wording “outside of MG” here means that PRS measurement is not inside MG, including the case when no MG is configured to the UE and the case when the existing MG cannot be used for PRS measurement. |

**FL summary:**

Among the companies providing the reponse

* Support (8): vivo, InterDigital, CMCC, OPPO, MTK, CATT, Ericsson, Huawei, Xiaomi
* Not support (2): Qualcomm, Intel
* Need further study (1): ZTE
* Unclear (1): Nokia

The FL also aknowledge the potential impact if such an enhancement is supported, including the aspect Qualcomm/Intel listed, but perhaps these can be further studied.

### Round 2

Based on the discussion of the GTW session. The proposal 3.1.2-1 is updated below. Companies are encouraged to check if the proposal is agreeable.

**Proposal 3.1.2-1 (rev1):**

* PRS measurement without MGs subject to UE capability is supported in Rel-17.
* The following aspects are FFS
  + PRS processing prioritization window
  + Mechanism to trigger UE DL PRS measurements and report
  + Bandwidth/numerology relationship and potential switching from(to) active DL BWP to(from) DL PRS bandwidth
  + UE/gNB assumptions on processing of DL PRS and other DL physical channels / signals
  + Potential restrictions on gNB behavior
  + UE DL PRS processing capabilities
  + Impact on deployment scenarios, including
    - Single gNB with multiple TRPs
    - Serving gNB and multiple neighbor gNBs

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | Suggest to remove third sub-bullet in FFS. And revise the main bullet as following,   * PRS measurement without MGs subject to UE capability is supported in Rel-17, further study the following options,   + Option 1: DL PRS is inside active BWP   + Option 2: DL PRS is inside serving cell, where the bandwidth of DL PRS is outside active BWP   + Other options are not precluded.   + Depending on the progress of latency improvements with respect to PRS measurement with MG, none/one/multiple of the above options should be adopted in Rel-17. |
| OPPO |  | First, we also suggest to remove the 3rd sub-bullet.  Secondly, we do not think the Option 2 proposed by ZTE is feasible. The UE definitely can not measure DL PRS outside BWP if no MG.   * PRS measurement without MGs subject to UE capability is supported in Rel-17. * The following aspects are FFS   + PRS processing prioritization window   + Mechanism to trigger UE DL PRS measurements and report   + ~~Bandwidth/numerology relationship and potential switching from(to) active DL BWP to(from) DL PRS bandwidth~~   + UE/gNB assumptions on processing of DL PRS and other DL physical channels / signals   + Potential restrictions on gNB behavior   + UE DL PRS processing capabilities   + Impact on deployment scenarios, including     - Single gNB with multiple TRPs     - Serving gNB and multiple neighbor gNBs |
| Huawei, HiSilicon | Yes | Just to would like to reply to QC’s comments made before the GTW session.  Even if we focus on MG enhancement e.g. via dynamic activation, there should be a corresponding request terminated at the serving gNB to trigger the serving gNB to activate the corresponding MG, which already causes additional signaling delay.  For Gap-less PRS measurement, there exist cases when no additional request is needed at all, and even for the cases when the BWP switching is needed, similar request can be sent to the gNB.  We think for IIoT case, the typical deployment should be that the BS providing cell service also provides the positioning service on the same carrier, because it reduces the cost, and it can have a single unified network to support both communication and positioning, which is the benefit of cellular positioning. With this condition, it is highly like that the BW and the numerology of the active DL BWP is the same as or at least can cover the PRS BW, when no BWP change is needed.  In this sense, we consider Gap-less PRS measurement an important feature to reduce latency.  For potential latency impact on PRS processing without MG and potential collision with data, we cannot simply say that the latency will increase as the overall latency depends on the deployment (number of TRP to measure, number of PRS resources per TRP), the data scheduling restriction, PRS processing priority, etc. All those issues cannot be discussed if we do not agree to support Gap-less measurement in the first place. |
| Xiaomi | Yes | We think the third sub-bullet intend to the case that PRS BWP is different from the active BWP, and is one of configured BWPs of UE. Thus BWP switching is needed to perfrom PRS measurement and data recepetion on the PRS BWP. |
| vivo | Yes | Support this proposal. In terms of latency reduction, compared with MG, the advantages of PRS performing measurement in BWP are the following 2 points that are difficult to replace:   1. It can solve the latency increase caused by the mismatch between the PRS period and the MG period. The effective PRS measurement period is calculated by LCM(TPRS, TMG), which is the least common multiple of PRS and MG periodicity. For example, the the minimum MG cycle is 20ms, and the PRS cycle is 8ms. Using MG, the effective period of 8ms cannot be reached. 2. When a high-priority data demand and a high-priority positioning demand exist at the same time, the gNB needs to consider the problem of data interruption caused by the configuration of the MG, so it may reject or postpone the MG request. This will also lead to latency increase for PRS measurement. However, if the UE is supported to measure the PRS in the BWP, at least the UE is given the opportunity to receive both high-priority data and high-priority PRS at the same time. For example, UE can process the PRS is in a carrier and receive the data is in another carrier.   In summary, we think UE performing PRS measurement within BWP is just an alternative to using MG, which makes it more flexible to assist PRS measurement for different cases.  In addition, in our opinion, the third sub-bullet should not be excluded at this stage, since it is basic BWP behavior and we can further study it. |
| CATT | Yes | For the last bullet, maybe it should be: “Impact of deployment scenarios on PRS measurement without MGs …” |
| Qualcomm | No | Thanks to HW and vivo for the good technical discussion.  We are doing enhancements to MG for the purpose of reducing latency and not for efficiency or other reasons. What is already latency-optimal for the Rel-16 PRS processing is that the UE is doing the processing uninterrupted and “with maximum priority” for a UE-requested period of time.  To vivo: For (1), we can simply introduce smaller MG periodicity. Looks much simpler than introducing a whole new feature. For (2) optimizing the coexistence of a “high-priroity” data & high-priority PRS while doing processing for both is NOT done for achieving low-latency PRS. It is done for coexistence between 2 very demanding features, which will result into worse latency for BOTH features. For us, it is really a corner case, and not the intention of a first release with low-latency PRS processing. I would like to remind people that we are talking about a PRS latency that is an order of magnitude less than rel-16; Lets see if this is possible in rel-17 and lets discuss about multiple high-priority channels/collisions at a later release.  To HW: Everything else equal (e.g. number of TRP to measure, number of PRS resources per TRP, the data scheduling restriction, PRS processing priority), if a UE has a window of maximum-PRS-priority (as already it has in rel-16), it will do ***faster*** processing than the case of removing that window no?  So, why change something that is already optimal for low-latency PHY PRS processing?  Most of the arguments about sub-optimality of current MG-based PRS-latency are either related to signaling/configuration aspects, or either about PRS/data flexibility (not really within scope of latency reduction).  Having said the above, the only baseline framework that we can discuss from our side is a framework which preserves the “latency-optimal” features of MG-based processing as a starting point of designing a low-latency feature of MG-less processing. That is, the starting point should be something like the following:   * *PRS measurement without MGs subject to UE capability is supported in Rel-17.*   + *At least support high-priority PRS measurement & processing within a window during which the UE is expected to prioritize the measurement & processing of PRS over the reception & processing of other DL channels, DL Reference signals and associated DL procedures.*   *Define new PRS processing capabilities* |
| InterDigital | Yes | We support the FL’s proposal. |
| Nokia/NSB | No | Agreeing on this proposal without understanding the details is not possible for us. Suggest to study further and also list options of within active BWP and outside active BWP to be discussed at next meeting. |
| Huawei, HiSilicon |  | To QC:  It looks like from QC perspective, you would like to agree MG-less PRS measurement and a higher priority of PRS processing over data/RS at the same time. It may be asking too much for the first meeting, and we believe that given the low latency target, when we decide the PRS-data/RS processing priority, having higher priority for PRS will be one option agreeable. However, there could be other alternatives to prioritize PRS reception, e.g. using scheduling restriction which is also listed here.  To Nokia:  Would it be OK for Nokia to consider the following revised proposal?   * PRS measurement without MGs subject to UE capability is supported at least when the numerology of the PRS is the same as the current active DL BWP and the bandwidth of the PRS is within the current active DL BWP in Rel-17. |
| LG |  | We are open to discuss it. We are also agree that it has obvious advantage in terms of latency reduction. On the other hand, as QC said, we need to first discuss the validity of the issue since a lot of enhancement for MG has been discussed, such as proposal 4,4,1-1. After that, we would like to list options depending on the discussion. |
| Ericsson | Yes (with some narrowing of scope) | Given the comments from Nokia and the other companies, we suggest to narrow the scope of the proposal to the following:   * + DL PRS is in the serving cell and inside the active BWP   with this narrowed scope, we think the third and the last sub-bullets can be removed from the FFS items. The remaining details regarding processing capabilities can be discussed during UE feature discussion. Proposal 3.1.2-1 (rev1):  * PRS measurement without MGs subject to UE capability is supported in Rel-17 where DL PRS is in the serving cell and inside the active BWP. * The following aspects are FFS   + PRS processing prioritization window   + Mechanism to trigger UE DL PRS measurements and report   + ~~Bandwidth/numerology relationship and potential switching from(to) active DL BWP to(from) DL PRS bandwidth~~   + UE/gNB assumptions on processing of DL PRS and other DL physical channels / signals   + Potential restrictions on gNB behavior   + UE DL PRS processing capabilities   + ~~Impact on deployment scenarios, including~~     - ~~Single gNB with multiple TRPs~~     - ~~Serving gNB and multiple neighbor gNBs~~   Regarding the use case perspective, we have similar views as Huawei and vivo. An IIoT use case may involve URLLC support with positioning as an add-on feature. In this scenario, prioritizing PRS only does not make sense. We should not do low latency positioning at the expense of hurting URLLC performance/latency targets. |
| Qualcomm |  | To HW: I appreciate the discussion. However, we are not starting from scratch a new “G”; nor we can go the time back in NR Rel-16 and the reasons that MG-less PRS was not agreed. The reality is that in NR rel-16, a UE already can do fully uninterrupted (even across all NR/LTE bands, since the MG is a “per-UE” feature) PRS processing. In other words, a UE can stop everything else (NR, LTE, FR1, FR2, all of it) to just do Positioning. This is the definition of the lowest processing we can get with regards to PHY-layer processing. The starting point should be the same, if we want to further optimize the latency, and not to turn back to simultaneously doing PRS with other stuff; How can that discussion be related to latency?  UE-capability-based PRS measurement/processing window is really essential to build on top of the previous feature and further reduce the latency with additional enhancements.  To make the feature useful, it is also really essential the gNB to know when the PRS is going to be measured; otherwise we ll be limited to a few deployments and out-of-spec coordination between gNBs and LMF. We want to avoid that also, otherwise the feature will not be implemented for sure if all parties do not understand how it will work. However, for the sake of progress, we could accept this to be an item that will be further discussed, and hopefully result into a reasonable (and useful for realistic deployments) solution.  However, we cannot re-discuss that the main low-latency Positioning feature is the one that the UE has an uninterrupted opportunity to do measurements/processing. |
| CMCC |  | We are OK with the revised Proposal given by Ericsson to narrow down the scope. |

**FL summary**

Among the companies submitting comments to the proposal. There is support on the intention. A few companies expressed their concern. In particular

* ZTE, OPPO, Ericsson think that the third subbullet (Bandwidth/numerology relationship and potential switching from(to) active DL BWP to(from) DL PRS bandwidth) should be removed.
* Nokia also mentioned to further study measurement inside the BWP and outside BWP.
* LG prefer to discuss MG enhancement first.
* Qualcomm think that the PRS measurement without MG should not put PRS processing interrupted, since Rel-16 MG-based PRS measurement already sets the high baseline when it comes to PRS processing time.

### Round 3

The FL has the following proposal update for Round 3. I would like companies to check if narrowing down the PRS to “from the serving cell” is agreeable.

**Proposal 3.1.3-1:**

* PRS measurement without MGs subject to UE capability is supported for latency reduction in Rel-17 at least when the DL PRS is [from the serving cell and] inside the active DL BWP.
  + Note: RAN1 strives not to increase the PRS measurement time compared with Rel-16 MG-based measurement
* The following aspects are FFS
  + PRS outside the active DL BWP
  + PRS processing prioritization window
  + Mechanism to trigger UE DL PRS measurements and report
  + UE/gNB assumptions on processing of DL PRS and other DL physical channels / signals
  + Potential restrictions on gNB behavior
  + UE DL PRS processing capabilities

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | We still prefer to further study the real benefits before we make the agreement. We think the priority of with MG and without MG for latency reduction should be the same. We’re not sure we have enough time to enhance both in Rel-17, but at least we should compare the actual benefits of enhancements for both with MG and without MG before we decide that enhancement for without MG has higher priority. |
| Ericsson | Yes | We are fine to support ‘from the serving cell’. Hence, the brackets can be removed from our perspective. |
| vivo | Yes | We think the latency of with MG and without MG may be same if only consider the best case. But the complexity and possibility for reaching the best-case is different. We cannot guarantee that the R17 MG enhancement will be the best-case.  But if the BW and the numerology of the active DL BWP is the same as or at least can cover the PRS BW, the best case can be easily achieved. |
| CATT | Yes | We prefer not to narrow down the PRS to “from the serving cell”, but we are fine to keep it in braket. |
| InterDigital | Yes | We are also fine to keep the square bracket. |
| Intel | Comments | We still prefer to further study the reasonable options to support the solution. If such options were found, then we are OK to support that enhancement. Additional details such as numerology of active BWP and DL PRS need to be added to the first bullet. Also how the LMF and gNB are aware that DL PRS is inside of the active BWP. |
| Nokia/NSB |  | We agree with Intel’s comments. Right now we are introducing a UE capability that may in fact be more restrictive than some UE implementations in Rel-16 (due to the serving cell part) and therefore this may not be gaining us much. We think it may be better to list some options and study further til next meeting:   * Option 1: w/o MG for serving cell and inside active BWP * Option 2: w/o MG for all cells and inside active BWP * Option 3: w/o MG outside active BWP |

Based on the comments received, Intel and Nokia expressed concern to agree to the enhancements and suggested further study. Other companies also have different views whether the “serving cell” should be a valid restriction. There is also a request to add numerology to the condition.

The FL updated the proposal as below.

**Proposal 3.1.3-2 (GTW):**

* Further study the following options to support PRS measurement without MGs for latency reduction in Rel-17
  + Option 1: The PRS is from the serving cell and inside the active DL BWP [with the same numerology]
  + Option 2: The PRS can be from the serving cell and non-serving cell, and is inside the active DL BWP [with the same numerology]
  + Option 3: The PRS is outside active DL BWP [or with the different numerology]
  + Note: RAN1 strives not to increase the PRS measurement time compared with Rel-16 MG-based measurement
* The following aspects are FFS
  + PRS processing prioritization window
  + Mechanism to trigger UE DL PRS measurements and report
  + UE/gNB assumptions on processing of DL PRS and other DL physical channels / signals
  + Potential restrictions on gNB behavior
  + UE DL PRS processing capabilities

### Round 4

Based on the GTW discussion, the following proposal is identified for further discussion and refinement of the wording. Companies are encouraged to provide views on the aspects including but not limited to

* Whether the numerology should be considered, or alternatively how to deal with the brackets
* Whether Option 3 wording needs further refinement

### Proposal 3.1.4-1:

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | We have two comments,   1. The all contents in bracket can reformulated as [with the same or different numerology]. We can decide in following meetings on whether the numerology should be the same or different from active BWP. 2. We would like to add another note.  * Note: Depending on the comparison of latency benefits between introducing MG-less PRS measurements and MG-based PRS measurements, none/one/multiple of the above options should be adopted in Rel-17. |
| Vivo | Yes | Okay for [with the same or different numerology] |
| Xiaomi | Yes | I think Option 3 with [or with the different numerology] already covers Option 1 and Option 2 with [with the different numerology] by this version. |
| Qualcomm |  | We support the Note by ZTE. |
| CATT |  | Fine with ZTE’s motification of [with the same or different numerology]. |
| Nokia/NSB |  | We support the proposal and note from ZTE. |
| InterDigital | Yes | We are ok with the modification proposed by ZTE regarding as [with the same or different numerology]. |
| Apple2 | Yes | OK with ZTE’s note. |
| SONY |  | Fine with ZTE’s note with the following revision:  Note: Depending on the comparison of latency benefits between introducing MG-less PRS measurements and MG-based PRS measurements, ~~none/one/multiple of~~ whether the above option(s) should be adopted or not in Rel-17. |
| CMCC | Yes |  |
| FL |  | The proposal is updated according to the comments received so far.  Note that for Option 3, I do not think adding “the same or” makes much sense. So my interpretation is that   * Either Option 1/2 go with the same numerology, and Option 3 goes with different numerologies * Or Option 1/2 go with the same or different numerology, and Option 3 goes without brackets at all. |
| ZTE |  | Thanks for FL’s updates.  For Option 3, we can simply remove the contents in bracket since it doesn’t matter whether is the same or different numerology. |

## 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. |
| Nokia/NSB |  | We are not clear on what option 1 would entail and has unclear UE behavior. For option 2 we are supportive. |
| Intel | Comments | These options need to be further studied |

**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. |
| Nokia/NSB |  | Depends on the intention of Proposal 3.1.1-1 |
| Intel | Comments | Before discussing this point, we would like to understand whether DL PRS processing will be performed within active BWP and potential bandwidth relationship with the frequency layer |

**FL summary:**

Among the companies providing the reponse to PRS processing on the same symbol as data/other PRS

* Support (11): vivo, InterDigital, OPPO, MTK, CATT, Ericsson, Sony, Huawei, Xiaomi, LG, Nokia
* Not support (1): Qualcomm
* Postpone (2): ZTE, Intel
* Unclear (1): Samsung

Option 1 is not supported by majority of companies, and thus is removed.

Among the companies providing the response to the existing agreement made in Rel-16, there is almost no support, and there is explicit objection to follow the existing agreement. This issue is no longer required to discuss as Rel-17 may have different requirement than Rel-16.

### Round 2 (closed)

Taking all the comments into account, the FL has the following update proposal.

**Proposal 3.2.2-1:**

* If PRS measurement without MG is supported, with regard to UE behaviour for PRS processing on the same symbol as data and other RS for PRS measurement without MG, define the priority rules between PRS and data/other RS
  + 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 |  | Postpone the discussion. It’s enough to only agree Proposal 3.1.2-1 in this meeting . |
| OPPO |  | Suggest to change the outside to without. Secondly, we suggest to study how to define the priority rules, instead of agreeing a broad statement to define priority rules. It is preferred to dicuss each particular rules.   * If PRS measurement ~~outside~~ without MG is supported, with regard to UE behaviour for PRS processing on the same symbol as data and other RS for PRS measurement ~~outside~~ without MG, study to define the priority rules between PRS and data/other RS   + 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   FL comment: Only adopted the change to align with wording. For whether “study” is added, would like to hear more views. |
| Xiaomi | Yes |  |
| vivo | Yes |  |
| CATT | Yes |  |
| InterDigital | Yes |  |
| Nokia/NSB |  | Not Fully sure this agreement is needed if we don’t progress on proposal 3.2.2-1 |
| Ericsson | Yes | We are fine with FL proposal. |
| CMCC | Yes |  |
| Sony | Yes |  |

**FL summary**

Since this is related to the progress in 3.1, the discussion is closed for this meeting. Companies are encouraged to discuss this issue in the next meeting.

## 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 (closed)

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 agreed  2, 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 gaps  We 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 |  |
| Nokia/NSB |  | We think that it may be too early to directly agree to support this feature but we are open to studying it further. |
| Intel | Comments | We assume that switching may not be needed if gNB allocates active DL BWP within DL PRS frequency layer bandwidth and both have the same numerology |
| ~~FL~~ |  | ~~To Nokia, currently the proposal does not preclude either case, which can be subject to further study.~~ |

**FL summary:**

Among the companies providing the reponse

* Support (2): vivo, CMCC
* Not support (5): OPPO, Ericsson, Qualcomm, Huawei, Samsung, LGE, Intel
* Postpone (4): ZTE, MTK, CATT, Nokia
* Unclear (1): Xiaomi
* Wording suggestion (1): MTK

There is no majority support for this feature. There is no need to further discuss it this meeting. Interested companies are encouraged to bring their contribution in the next RAN1 meeting to justify the necessity to define positioning-dedicated BWP or BWP adaptation for the cases when the current active DL BWP does not match the PRS bandwidth..

## 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 (closed)

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.

|  |  |  |
| --- | --- | --- |
| **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. |
| Nokia/NSB |  | Need to wait for progress and clarity on proposal 3.1.1-1 first. |
| Intel | Yes, with comments | Before agreeing on introduction of this capability, we would like to have clear understanding on basic operation principles without configured MG |

**FL summary:**

Among the companies providing the reponse

* Support (8): vivo, OPPO, Lenovo, Ericsson, Huawei, Samsung, LG, Intel
* Postpone (2): ZTE, Nokia

The feature has majority support. However there was concern to wait for the conclusion whether PRS measurement outside MG is supported.

Given that progress in 3.1 is still pending, this discussion is closed. Interested companies are encouraged to discuss this issue in the next RAN1 meeting.

## 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

|  |  |  |
| --- | --- | --- |
| **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. |
| 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. |
| Nokia/NSB |  | Not sure this is a RAN1 decision to make. We need to better understand this solution first and potentially involve RAN4. |
| Intel | YES | Agree with the proposal |

**FL summary:**

Among the companies providing the reponse

* Support (12): vivo, InterDigital, CMCC, OPPO, Lenovo, CATT, Qualcomm, SONY, Huawei, Xiaomi, Samsung, Intel
* Not support (1): Ericsson
* Consult RAN4 (2): ZTE, Nokia

The proposal has majority support, with concern from two sources that RAN4 should make the decision. One source consider it low priority given the nature of periodic PRS measurement.

### Round 2

Taking all the comments into account, the FL has the following update proposal.

**Proposal 4.1.2-1:**

* Send an LS to RAN4 informing that
  + Preconfiguration of multiple MGs and subsequent triggering/activation with lower layer signalings (DCI or MAC CE) are beneficial for positioning measurement latency reduction from RAN1 perspective.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| ZTE |  | OK with the LS. We should say the intention is to reduce positioning latency . |
| OPPO |  | Agree with ZTE, it is better to clarify the intention   * Send an LS to RAN4 informing that   + Preconfiguration of multiple MGs and subsequent triggering/activation with lower layer signalings (DCI or MAC CE) are beneficial for positioning measurement latency reduction from RAN1 perspective.   FL comment: added. |
| Xiaomi |  | OK with the LS |
| vivo | Yes |  |
| CATT | Yes | Suggest changing “Preconfiguration of one or more MGs…”, assume the preconfigured MG can be one. |
| Nokia/NSB |  | Okay in principle. |
| Lenovo,Motorola Mobility | Yes | Support |
| LG | Yes |  |
| Ericsson | no | Currently, there is no consensus to introduce Aperiodic PRS or Semi-persistent PRS in NR Rel-17. Could the proponents answer why DCI triggered or MAC CE activated MGs are beneficial?  We cannot agree that this is beneficial unless the proponents can explain the use case for this. |
| Qualcomm | Yes | High priority.  To E//: The UE gets a location request, and instead of spending the RRC-time to send a MG-request and get a response (20-40 msec),   * It receives a DCI by the gnB or DL-MACCE (the gNB got an NRPPa message at the same time that the UE got the location request) to schedule a specifc MG. 3 msec latency OR * it sends a UL-MAC to request one of the pre-configured ones (3 msec),   In either scenario, the 20-40 msec of RRC-based request/response is reduced down to a handful mseconds. |
| CMCC | Yes |  |
| SONY | Yes |  |
| Ericsson |  | To QC: thanks for the clarification.  we can see that DCI would be faster than RRC, but even if we save one RRC message between the UE and gNB, the additional NRPPa message between the gNB and the LMF will also cause additional latency. One way forward would be to discuss the architecture of the solution in RAN3 to see if it is feasible with the expected gains, so we we could discuss an LS to RAN3 to discuss this issue. |
| InterDigital | Yes |  |
| Intel | YES |  |

**FL summary**

Among the companies commenting on the second round, there is majority support, and the concern from only source seems to be addressed.

It is suggested to proceed with the Round 2 proposal.

|  |  |  |
| --- | --- | --- |
| Qualcomm2 | No | High priority.  Need to update our views for the following reason: We believe that different companies may have different understanding on the following:   * When we say “DCI or MAC-CE” does it mean both are beneficial or one or the other is beneficial? * When we say MAC-CE, do we mean DL-MAC-CE or UL-MAC-CE. From our side, we were talking about UL-mACE (i.e the 2nd solution shown in our previous reply), but after observing the reply from E// it seems that the debate may be more about the 1st solution. * RAN4 does not know whether RAN1 has in mind the 1st or 2nd solution. Also, if it is the 1st solution, indeed there is RAN2 & RAN3 impact, which may result to higher latency. * We consider the option of having “all the spec-potential MGs” as one case of “preconfiguration” (the default/legacy case), which also does not have an additional signaling. However, this is not clear in this LS to RAN4. * So, there needs to be further discussion in RAN1 before sending an LS, to clarify what RAN1 wants the design to be. |

### Round 3

To the change of positioning of a companies, the FL is encouraging companies to check whether we go with the Proposal 4.1.2-1 or reverse the course for further study.

**Discussion point:**

* Whether companies would like to go with Proposal 4.1.2-1 or further study the preconfiguration of MGs with subsequent activation via lower layer signaling.
  + Alt. 1 Proposal 4.1.2-1
  + Alt. 2 Further study the mechanism

|  |  |  |
| --- | --- | --- |
| **Company** | **Position** | **Comments** |
| Qualcomm2 |  | High priority.  Need to update our views for the following reason: We believe that different companies may have different understanding on the following:   * When we say “DCI or MAC-CE” does it mean both are beneficial or one or the other is beneficial? * When we say MAC-CE, do we mean DL-MAC-CE or UL-MAC-CE. From our side, we were talking about UL-mACE (i.e the 2nd solution shown in our previous reply), but after observing the reply from E// it seems that the debate may be more about the 1st solution. * RAN4 does not know whether RAN1 has in mind the 1st or 2nd solution. Also, if it is the 1st solution, indeed there is RAN2 & RAN3 impact, which may result to higher latency. * We consider the option of having “all the spec-potential MGs” as one case of “preconfiguration” (the default/legacy case), which also does not have an additional signaling. However, this is not clear in this LS to RAN4. * So, there needs to be further discussion in RAN1 before sending an LS, to clarify what RAN1 wants the design to be.   FL comments  1st comment: My understanding is that both are beneficial, but would like to hear proponents to clarify. Whether both will be adopted or either or neither will be further investigated.  2nd comment: I am assuming DL MAC CE. For UL MAC CE, I guess it is related to 4.2 MG request enhancements.  3rd comment: What are the 1st solution and the 2nd solution in the context? Maybe I missed something. Does 1st solution refers to UE requests the MG and 2nd solution refers to LMF requests the MG? If that is the case, I am assuming MG request enhancements should be discussed when we agree the general support of lower layer triggered MG for preconfigured MG.  4th comment: This dynamic indication of MG index without configuration at all can be further discussed, but to my understanding, besides the MGL and MGRP defined in TS 38.133, the MG offset should be configured.  5th comment: I would like to check if companies feel comfortable to further study this issue. |
| ZTE |  | We tend to agree to further study this proposal. As the questions raised by Qualcomm, there are so many issues that different companies may have different views.   1. Does RAN1 plan to support both DCI and MAC CE? Or after we compare the benefits, we may select one of them. 2. Our original understanding is that both DCI and MAC CE are for DL, which is to replace the RRC measurement gap configuration from gNB in Rel-16. 3. If measurement gap request is supported from LMF, we don’t really see the need to enhance the procedure for measurement gap configuration as RRC measurement gap configuration from gNB and provide assistance data can be conducted in parallel. |
| Vivo |  | Further study of the issue in RAN1 from the perspective of positioning and to reach a consensus in RAN1 may be beneficial for the latency requirement since the positioning parameter and procedure are defined in RAN1. So, we think identifying the effective parameter, configuration and procedure of MG enhancement on latency reduction can be part of RAN1 work. Only the enhancement is clear in RAN1, the guidance to RAN4 will be clear.  So, we propose   * RAN1 to further study at least the following aspects for MG enhancement from the perspective of positioning   + Preconfiguration of multiple MGs   + Triggering/activation MG with lower layer signalings (DCI or MAC CE) |
| Xiaomi |  | We slightly prefer Alt 1 since either MAC CE or DCI are beneficial for positioning measurement latency reduction |
| Qualcomm |  | Thanks to HW for the clarification. We don’t think that 4.1 and 4.2 should be split. Sending a MG indication in the DL, is just one side of the story, we need to have a complete solution in mind, otherwise we risk not understanding what latency gains we are talking about.   * RAN1 to further study at least the following aspects for MG enhancement with regards to MG requesting and configuration/activation/triggering for the purpose of latency reduction for positioning:   + Preconfiguration of multiple MGs   + Triggering/activation MG with lower layer signalings (DCI or DL MAC CE)   + Request of MG with lower layer signaling (UL MAC CE)   + Request of MG by LMF indication to the gNB |
| CATT |  | We support Proposal 4.1.2-1 (Atl.1). In the meanwhile, we are also fine to further study other mechinisms that are not included in Proposal 4.1.2-1 (e.g., the 3rd and 4th bullets in Qualcomm’s comments. |
| Nokia/NSB |  | We think that there is not common understanding from companies on this issue so it may be better to continue discussion at the next meeting before making any concrete agreements. |
| InterDigital |  | Although we lean toward Alt. 1, Alt. 2 is also ok with us, to clarify details for fast configuration of MG. |

**FL summary:**

It looks like most companies can be flexible on further study this aspect. The FL has the following proposal update based on the wording suggestion from vivo/Qualcomm, and some wording suggestions. Companies are encouraged to provide their views.

### Proposal 4.1.3-1 (Input requested):

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Apple2 | See comments | We support the intention (and we think too early to send LS to RAN2). On the above proposal, we would like to remove the first bullet (which is under RAN2 expertise). We support all the other bullets.  FL: I tent to think that there is a strong request to include this bullet based t-doc submission. Would Apple be flexible to consider listing here, since it is study anyway. |
| MTK | Yes in principle | 1, just for clarification that the “multiple MGs” is to say different measurement, for example mobility measurement and positioning measurement belong to different MG configuration. It is not to say positioning measurement could be conducted through multiple MGs  FL: I think whether the multiple MGs are used for RRM-only, positioning-only, or positioning+RRM sharing can be further studied.  2, It seems that for the 4 bullets, some of them could be jointly realized. They are not completely separate story. We are okay for the current lists, and want to say that the combination of some items are very possible. Maybe the FL can add a note  FL: Added. |
| Lenovo,Motorola Mobility | Yes | Suggest a minor update to fully differentiate the 3rd and 4th bullet:” Request of MG by UE with lower layer signaling (e.g. UL MAC CE)” |
| vivo | Yes | 1. we prefer to remove the bracket of the third sub-bullet. And modify as follows   * + Request of MG with lower layer signaling by UE to the gNB ~~(e.g. UL MAC CE)~~   2. If some companies worry about the description of the first sub-bullet, Maybe we can change it to “ the maximum number of configurable MGs and the potential impact on MG parameter” |
| CMCC | Yes in principle | One thing to be clarified, when we say triggering/acitivation and request of MG in the 2nd and 3rd bullet, does it intend to only one MG, or it can be one or more MGs?  FL: I think this does not preclude either case. I added (s) for the third and the fourth bullet. |
| FL |  | I provided some reply inline, and update the proposal based on comments so far. |
| Intel | Yes |  |
| ZTE | Yes in principle. | We would like to revise the following bullet, whether the MGs can be determined by LMF or not can be also for further study,   * + Request**/determination** of MG(s) by LMF indication to the gNB**/UE** |

## 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 (closed)

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.

|  |  |  |
| --- | --- | --- |
| **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. |
| Nokia/NSB | Yes | Okay to study further. |
| Intel | YES with comments | It only makes sense if the dynamic mechanism for MG signaling is supported |
| LG | Yes |  |

**FL summary:**

This proposal has majority support, with two sources considering it low priority.

Despite the FFS nature, the FL suggest to attempt to capture it in the notes. If this cannot be agreed, interested companies are encouraged to bring their contribution in the next RAN1 meeting to provide the details of MG request signaling that can show latency reduction.

**FL comment update:**

Based on the discussion in 4.1, companies felt comfortable to discuss MG configuration/activation and MG request jointly. So the discussion of MG request is merged into 4.1, and the discussion here is closed.

## 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 (closed)

The FL has the following tentative proposal.

**Proposal 4.3.1-1:**

* Further study whether the MG pattern can be enhanced.

|  |  |  |
| --- | --- | --- |
| **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. |
| Nokia/NSB |  | Agree with CATT and other this is RAN4. |
| Intel | YES | It should be studied in RAN4 |

**FL summary:**

There is no majority support on the study. Given that the proposal is “FFS” in nature, there is no need to further discuss it this meeting. Interested companies are encouraged to bring their contribution in the next RAN1 meeting or propose it directly in RAN4.

## 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 |  |
| Intel | YES | OK to further study |
| Lenovo,Motorola Mobility | Yes | Open to study further |
| Qualcomm | Yes | High priority to study further enhancements that could reduce the latency of the Rel-16 MG-based PRS processing. |

**FL summary:**

There is majority support on the study. Despite the “FFS” nature, it is recommended to be captured in the notes. If this cannot be agreed, interested companies are encouraged to bring their contribution in the next RAN1 meeting on those aspects.

### Round 2

Normally we do not have to agee to any “study issue” in the WI phase. Companies are encourage to provide views on whether proposal 4.4.1-1 should be treated in the GTW if time allows given that there is overwelming support for further study.

### Discussion point (Input requested):

* Is there any need to treat proposal 4.4.1-1 in the GTW if time allows?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Lenovo,Motorola Mobility | Yes |  |
| Intel | No | OK to further study. |
| ZTE | No | The scope is too broad, we don’t have time to nail down the specific enhancements.We prefer to further discuss those issues separately in next meeting. |
|  |  |  |

# 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**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia/NSB | During the SI phase some companies proposed we investigate SRS priority enhancements and it was discussed these could be brought during the WI directly. We suggest taking this discussion up at this meeting or in the following meetings. As SRS for positioning has low priority it has a negative impact on the positioning latency. |
|  |  |
|  |  |
|  |  |
|  |  |

**FL summary:**

Nokia mentioned that SRS priority enhancement was discussed in the SI, and suggest to consider it in the WI with the justification of latency. Companies are encouraged to provide their view whether enhancements on SRS priority is in the WI scope.

## Round 1

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

**Proposal 5.1-1:**

* RAN1 to confirm whether support of SRS priority enhancement is in the WID of Rel-17 positioning.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| InterDigital | Yes | Since the scope for latency reduction includes DL+UL positioning methods, SRS priority enhancement to reduce latency is within the scope of the WID. We support to study priority enhancement for SRS for positioning. |
| Nokia/NSB | Yes |  |
| LG | YES |  |
| ZTE |  | We don’t think the SRS priority is within the current scope of “Latency reduction related to the time needed to perform UE measurements; [RAN1, RAN4]”. since the measurement time of UE Rx-Tx time difference doesn’t depend on the SRS based on the definition of Rel-16. |
| vivo | Yes | To ZTE, it may be related DL+UL latency reduction |

**FL summary**

There is limited input from companies. I will check later to see if we can have a second-round proposal for Monday’s GTW session.

## Round 2

Normally we do not have to agee to any “study issue” in the WI phase. Based on the input received so far, it seems most commenting companies felt the enhancement is included in the WID. The FL think that it is useful to capture this in the Note that so interested companies can be encouraged to provide inputs on this aspect in the next RAN1 meeting.

### Proposal 5.2-1 (Input requested):

* Further study SRS priority enhancements for the purpose of latency reduction.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Apple2 | No | Not sure why this is given high priority for GTW discussion (views provided are not extensive) |
| Lenovo,Motorola Mobility | Yes | Since its only study issue, open to capture this in the notes. |
| CMCC | Yes | In the SI phase, this issue was raised and concluded that it can directly start in the WI phase. |
| ZTE |  | Not for this meeting for lack of discussions. |

# Summary

TBD