3GPP TSG-RAN WG2 #113e R2-21xxxxx

Electronic meeting, January 25th – Feb 5th, 2021

Agenda Item: 8.11.2

Source: Ericsson

Title: Report on [Post112-e][608][POS] Support of on-demand PRS

Document for: Discussion, Decision

# 1 Introduction

This document addresses the following email discussion:

* [Post112-e][608][POS] Support of on-demand PRS (Ericsson)

 Scope: Discuss potential solutions for on-demand PRS: signalling aspects, which node requests the PRS, which node the request is directed to. Rapporteur is asked to provide update on RAN1 agreements.

 Intended outcome: Report to next meeting

 Deadline: Long

Section 2 provides information on RAN1 agreements.

Section 3 contains the questionnaire on various aspects of “On demand PRS”. The purpose is to collect the views and identify the commonalties and differences in order to provide proposals for way forward.

# 2 RAN1 Agreements

Agreement:

Capture the following in the TR [1]:

From a physical layer perspective, on-demand transmission and reception of DL PRS, which includes at least the following is recommended

* + UE-initiated request of on-demand DL PRS transmission
	+ LMF (network)-initiated request of on-demand DL PRS transmission
* Above enhancements are recommended for both DL and DL+UL positioning methods and both UE-based and UE-assisted positioning solutions.

# 3 On Demand PRS

## 3.1 Objective

The SID [1] has different objectives such as RS overhead reduction, latency reduction etc.

1. Study enhancements and solutions necessary to support the high accuracy (horizontal and vertical), low latency, network efficiency (scalability, RS overhead, etc.), and device efficiency (power consumption, complexity, etc.) requirements for commercial uses cases (incl. general commercial use cases and specifically (I)IoT use cases as exemplified in section 3 above (Justification)):
	1. Identify and evaluate positioning techniques, DL/UL positioning reference signals, signalling and procedures for improved accuracy, reduced latency, network efficiency, and device efficiency.
	Enhancements to Rel-16 positioning techniques, if they meet the requirements, will be prioritized, and new techniques will not be considered in this case. [RAN1, RAN2]

Please describe what would be the objective that “on Demand PRS” should aim to fulfil (*from your perspective*). Please also explain in brief (Abstract) as how this can be achieved from the solution/signalling that is envisioned (*by you*).

**Companies are invited to provide their view**

**Please explain the objective and solution/signalling abstract**

|  |  |  |
| --- | --- | --- |
| Company | Objective | Abstract of Solution/Signalling |
| Huawei/HiSilicon | All | * Specify support for on-demand PRS for both DL and DL+UL positioning methods and both UE-based and UE-assisted positioning solutions
	+ Time-domain characteristics of PRS resource (e.g., periodic, semi-persistent, aperiodic PRS resource), CA/DC configuration [RAN1, RAN2]
	+ UE and network-initiated operations for the support of on-demand PRS [RAN2, RAN3]
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| OPPO | Network efficiency, accuracy，and latency reduction | 1. For network efficiency, on-demand PRS helps to avoid unnecessary PRS transmission, so that reduce RS overhead;
2. For accuracy, on-demand PRS helps to adjust PRS transmission in a UE-oriented manner, so that to improve the accuracy finally.
3. For latency, UE may need less time for sufficient measurement occasions to meet some requirement if on-demand PRS is supported
 |
| Qualcomm | EfficiencyLatencyAccuracy | Efficiency:On-demand DL-PRS avoids unnecessary overhead, waste of energy, etc. in the case that no UE positioning is required during a particular time or in a particular area of a network. In case of beamformed DL-PRS, DL-PRS transmission in all beam sweeping directions may result in an unnecessary transmission of DL-PRSs.Latency:The current DL-PRS configuration may not be sufficient to meet the response time requirements of the LCS client; e.g., may have a too large periodicity.Accuracy:The current DL-PRS configuration may not be sufficient to meet the accuracy requirements of the LCS client; e.g., may have a too small bandwidth, too few repetitions, etc..The LMF and UE should be able to recommend the desired parameters of the DL-PRS configuration including a desired DL-PRS bandwidth, a number and duration of DL-PRS positioning occasions, frequency and bandwidth, periodicity, desired directional DL-PRS beams, etc. |
| CATT | Network efficiencyLatencyAccuracy | 1.UE-initiated request of on-demand DL PRS transmissionOn-demand periodic/SPS/A-periodic DL PRS helps improve network efficiency.2.LMF-initiated request of on-demand DL PRS transmissionLMF may request on-demand DL PRS to gNB to improve the network efficiency. Meanwhile on-demand PRS configuration from LMF to gNB may also help improve the accuracy. |
| Xiaomi | Network efficiency LatencyAccuracy | On-demand PRS could improve the flexibility of PRS configurations and the PRS configurations requested by UE and/or LMF can better satisfy the requirements of LCS. Thus the network efficiency, positioning latency and accuracy can be improved by on-demand PRS. |
| Ericsson | RS Overhead, Network Efficiency | As specified in the SID, item 1; PRS might need to be transmitted in a beamformed fashion to compensate the higher path loss at higher carrier frequencies. The PRS transmission to all beam sweeping directions results in an unnecessary transmission of PRSs. Thus, a solution is required to identify a mechanism to optimize the PRS transmission. By selecting the optimum number of beams and beam directions for PRS transmission and by switching off the PRS transmission in a more opportunistic way, it should be possible to achieve network efficiency and reduce PRS overhead. For this to happen, * the UE should provide the RSRP result of PRS being transmitted from different beams to the LMF.
* LMF should compute the PRS utilization from different beams based on the report from UE.
* LMF should provide a list of low utilized or un-utilized beams to gNB to be turned off.
 |
| ZTE | All | NW&UE efficiency:We have the similar views with above companies about the efficiency improvement for both NW and UE. The on demand PRS can avoid unnecessary PRS transmission. And UE may be able to select a more appropriate PRS configuration, and may spend less time on the PRS measurement.Latency:From our mind, because the more appropriate PRS configuration, the on demand PRS may reduce the time spent on UE measurement. But compared with the Rel-16 “always on ” mode PRS, NW side may spend more time on exchanging information for the on demand PRS(e.g LMF distributes the PRS configuration to all involved gNBs). Whether there is any latency improvement or how much the latency improvement can be achieved depends on the further discussion and decision.Accuracy:We think whether on demand PRS can make contribution to the accuracy depends on the RAN2 agreements of this function. E.g. larger bandwidth may have benefit to the accuracy. But only “turn on&off PRS transmission” does not have any accuracy influence. |
| Intel | all | On demand PRS can improve efficiency based on on/off mechanism, and could increase the accuracy if the BW, etc can be adjusted. It can also reduce the latency since the network could reduce the periodicity of PRS or close the timing that the UE want to measure.  |

## 3.2 UE-initiated request for on-demand DL PRS

From RAN1 physical layer perspective, one of the agreements is as below

* + UE-initiated request of on-demand DL PRS transmission

RAN2 need to further evaluate and decide whether it is feasible in terms of signalling.

When it comes to UE-initiated request for on-demand PRS; there can be two different interpretations:

1. UE-initiated Request from Idle/Inactive similar to SI Request
2. UE-initiated Request during active LPP session

According to interpretation a), the UE-initiated request for on-demand PRS is similar to on demand SI. Based upon this, serving gNB should inform to LMF and LMF should then identify neighbor gNBs/TRPs and request for PRS transmission. An example of UE-initiated request according to interpretation a) is given in Figure 1.



 Figure 1: An example of UE initiated Request for On demand PRS using SI request Analogy

According to interpretation b), the UE in connected mode may request to modify the existing PRS configuration. For instance, the UE may request for denser PRS configuration or more repetitions, shorter periodicity, different frequency region etc. An example of UE-initiated request according to interpretation b) is given in Figure 2.



 Figure 2: An example of On demand PRS Based upon UE Request

**Companies are invited to provide their view**

**Please explain the objective to support UE-Initiated Request i.e what would it map to the above SID objective.**

**Please provide also your opinion on which version should be supported: either a or b, both or none.**

**For Option b) Please also provide the desired list for the PRS configuration parameters those can be changed via on demand procedure. For example: number of symbols, bandwidth, Frequency region, muting pattern, resource sets, resources, resource power etc.**

|  |  |  |
| --- | --- | --- |
| Company | Options (a, b, both, none) | Objectives |
| Huawei/HiSilicon | Option b | We think UE-initiated request (during active LPP session) is beneficial for improved accuracy, reduced latency, and device efficiency. For example, the UE can request PRS re-configuration when it finds the current PRS configuration suffers poor measurement quality.For Option b, we assume the request information can be categorized into following two types.* Type 1: Direct request of assistance data in the granularity of resource, resource set, frequency layer, TRP
* Type 2: Assistance information help LMF trigger on-demand PRS, e.g. PRS measurement, RRM measurement, etc.

For Option a (similar to SI request), we have a concern that how can UE obtain the updated PRS configuration. 1) If UE obtains the updated configuration through posSIB, UE can only request the PRS configurations from a certain subset.2) If the UE shall recover the RRC connection eventually, why not send the request after the RRC connection is established?3) If the INACTIVE mode provides general support for NAS message, why the UE cannot send the on-demand SI request in LPP message? |
| OPPO | Option-b | Option-a which is used to trigger PRS during INACTIVE/IDLE state would not be an efficient solution, since not only the request but also the subsequent configuration should be done via LPP, i.e., preferably applicable to CONNECTED UE, if the scheme is designed aiming at sufficient performance gain.Option-b: we have similar view as Huawei, i.e., the request from UE is not only to request the adjustment of detailed parameter of PRS being transmitted, but also to request to turn on/off the PRS transmission from TRPs. |
| Qualcomm | MO-LR + Option b) | Option a) requires a new procedure and new signalling and may be difficult to provide on a subscription basis. Option b) can be supported in the same way as the MO-LR option described below by adding new parameters in an LPP request for assistance data.To avoid new procedures and signaling and support a UE that is in any initial state, the Rel-16 MO-LR procedure can be used as described in R2-2010097. This only requires additional parameters in the LPP Request Assistance Data messages, i.e., including the desired parameters of the DL-PRS. The Request Assistance Data message can then be provided in the SS MO-LR Request (probably together with other LPP messages) to the LMF via an AMF. The actual on-demand DL-PRS network procedures can then be the same as for LMF-triggered on-demand PRS.We note that if Option b) is supported using LPP, then the MO-LR option would also (probably) be supported, and vice versa. |
| CATT | Option-b | LMF can provide more suitable PRS configurations based on UE request. But in option a, the UE can’t provide enough assistance info to the network with preamble. Option-b is more reasonable. |
| Xiaomi | Option-b | Option b can provide more flexible PRS configurations to UE.For option a, if idle UE wants to update the PRS configurations, we think it should transmit to RRC CONNECTED to perform on-demand PRS.Moreover, if the only serving gNB participates the UE positioning, the UE can send on-demand PRS request to the serving gNB and then serving gNB decides the PRS configurations. |
| Ericsson | none | For objective a) Clearly this mechanism involves lot of signaling and increases RACH load. Further, this cannot solve NW overhead since just for one UE, NW has to transmit PRS not only from serving cell but also from neighbor cell/TRPs.For objective b) generally, LMF as such has to cater for several UEs and it may not be able to tune the PRS config just for one UE. It still requires lot of signalling and is not guaranteed that gNB would be able to fulfil it. |
| ZTE | Option b | 1. Option b only needs to add some new parameters in the current used positioning mechanism. Meanwhile in option a, a new procedure about RACH should be introduced.
2. For option a, there is only limit PRS configuration alternatives for UE to be selected. And UE can not transmit enough assistance data which may help NW to configure appropriate PRS configuration for the UE to the NW. From the efficiency perspective, option b is a better option.
 |
| Intel | Option b | To our understanding, option b can also be used to control the on/off of PRS transmission, i.e. not only adjust the PRS configuration, and it could work for INACTIVE UE if LPP can be transferred via SDT. 1.
 |

## 3.3 LMF (network)-initiated request

From RAN1 physical layer perspective, one of the agreements is

* LMF (network)-initiated request of on-demand DL PRS transmission

RAN2 need to further evaluate and decide whether it is feasible in terms of signalling.

When it comes to LMF initiated request for on-demand PRS; there can be two different interpretations:

1. LMF dynamically varying PRS config
2. LMF recommending turning on/off beams to gNB

According to interpretation a) LMF may dynamically vary certain aspects of PRS configuration such as request for denser PRS configuration or more repetitions, shorter periodicity, different frequency region etc. depending upon UE measurements and location accuracy. An example of LMF-initiated request according to interpretation a) is given in Figure 3.



 Figure 3: An example of LMF-initiated request for on demand PRS

According to interpretation b) LMF may identify that certain beams are not contributing to positioning measurements or certain beams (based upon ECID, QCL-D info) which are currently disabled and should be enabled for PRS transmission; LMF may recommend the gNBs accordingly to switch on/off PRS beams. An example of LMF-initiated request according to interpretation b) is given in Figure 4.



 Figure 4: An example Signalling of LMF for PRS Overhead Reduction

**Companies are invited to provide their view**

**Please explain the objective to support LMF-Initiated Request i.e what would it map to the above SID objective.**

**Please provide also your opinion on which version should be supported: either a or b, both or none.**

**For Option a) Please also provide the desired list for the PRS configuration parameters those can be changed via on demand procedure. For example: number of symbols, bandwidth, Frequency region, muting pattern, resource sets, resources, resource power etc.**

|  |  |  |
| --- | --- | --- |
| Company | Options (a, b, both, none) | Objectives |
| Huawei/HiSilicon | Option b | We think LMF-initiated request is beneficial for improved accuracy, reduced latency, and network efficiency. For example, based on statistical results (e.g. calculation, measurement), LMF can trigger the request for more/dynamic PRS resources to improve accuracy or latency, or reducing/turning off some PRS resources to improve network efficiency in the case of less strict requirements.For option a, we think that all possible PRS configurations should be provided by gNB to LMF in advance. In case of different variants, it can be in e.g., different PRS resource sets, and by activating a specific PRS resource set, a certain configuration should be activated, which may introduce additional negotiation between the serving gNB and neighbouring gNBs. So we don’t think Option a provides an efficient solution. For option b, what needs to be further discusses is the granularity of indication for the ON/OFF indication. We assume that at the current stage, the granularity of indication can be resource-level, resource-set-level, and TRP-level. |
| OPPO | Option-a and Option-b | We fail to identify essential difference in terms of achievable performance gain by the two options, either by adjusting the detailed parameter in option-a, or to perform a turn-on/off operation in option-b. |
| Qualcomm | Both + Option c | Options a) and b) represent two extremes. A middle Option c) would be to support operator specific configurations of DL-PRS, where configuations are (e.g.) numbered. Each configuration can have a set of associated DL-PRS parameters (e.g. defining bandwidth, duration, power, periodicity, frequency range, muting etc.). A configuration could also correspond to no DL-PRS (the off state). Configurations would be defined using O&M and can avoid excessive signaling between an LMF and gNBs using NRPPa.We are in agreement for supporting all three options, though Option b) seems more like a special case of Option c).We also don’t think that procedures like those above are needed to define the Options as they are just examples of implementation. Instead, only the NRPPa procedure(s) are needed. |
| CATT |  | It is not clear what the difference between option A and option B is. Does it mean option A can only be used to increase PRS configurations and option B can only be used to adjust PRS configurations per beam level? |
| Xiaomi | Both | Both options can be supported since we think there is no essential difference between the two options. |
| Ericsson | Option b | Option b may only have NRPPa impact whereas Option a will have both LPP and NRPP impacts.To CATT: Yes; that is right. Option b is just to reduce PRS overheadPRS might need to be transmitted in a beamformed fashion to compensate the higher path loss at higher carrier frequencies. The PRS transmission to all beam sweeping directions results in an unnecessary transmission of PRSs. Thus, a solution is required to identify a mechanism to optimize the PRS transmission.  |
| ZTE | Both | We prefer to support both options. LMF may have the capability to modify the PRS configuration dynamically based on the measurement reports. Both beam level management and PRS parameter modification should be supported. In addition, the only different between option a in LMF initiated request and option b(LPP solution) in UE initiated request for on demand PRS(previous question) is the initiator of this procedure. There is no so much PRS overhead in option a if we decide to support the option b for UE-initiated on demand PRS. |
| Intel | Both +option C | Share the same view with QC. The main difference between option a and b is the detailed configured in NRPPa message, and should not be defined as option. The procedure should be, LMF decides to change the PRS configuration (or turn on/off), and then trigger the NRPPa procedure. It could also be triggered by UE-initiated request for on-demand DL PRS.  |

## 3.4 gNB based

**Companies are invited to provide their view on whether gNB based On demand PRS be considered. In such case UE may have to provide measurement results (RSRP) to gNB and gNBs may need to co-ordinate over XnAP interface.**

**Please provide also your opinion on such mechanism.**

|  |  |  |
| --- | --- | --- |
| Company | Options Yes/No (Yes: support, No: do not support) | Comments |
| Huawei/HiSilicon | No | We think it’s an inefficient way for gNB-based On demand PRS if UE-initiated and LMF-initiated on-demand PRS are introduced. Compared with the LMF-initiated/UE-initiated solution, the gNB-based one suffers several drawbacks:1. Additional signalling overhead would be introduced between UE-gNB and gNB-gNB when multiple gNBs are involved.2. There will be more spec impacts involving RRC and XnAP, while the LMF-based solution can reuse the current LPP and NRPPa messages.3. Not sure based on what information a gNB should request on-demand PRS in the neighbouring gNBs and based on what information gNB should accept the request from a neighbouring gNB to turn ON/OFF the PRS or increase/decrease the density of PRS |
| OPPO | No | XnAP-based coordination is obviously colliding with the DL-PRS configuration framework, which has been designed in a way to rely on LMF for inter-gNB coordination. |
| Qualcomm | depends | This depends on the location of the LMF. If LMF functionality resides in the gNB, gNB-based on-demand DL-PRS should be supported. If there is no LMF functionality in the gNB, then no gNB based on-demand DL-PRS needs to be supported. |
| CATT | No | This is not aligned with current framework of PRS configuration. We think it is enough to only consider UE-initiated request and LMF-initiated request for on-demand PRS. |
| Xiaomi | No | We think the LMF should coordinate the PRS configurations between different gNBs. |
| Ericsson | Yes | RAN3 already supports the exchange of CSI-RS for mobility purpose with very little impacts in XnAP. PRS can be supported in the same way. Provision of similar exchanges over XnAP may also additionally help to co-ordinate PRS config and reduce overheads. |
| ZTE | No | We share the similar view with Huawei.1. More signalling overhead may be introduced between UE&gNB and gNB&gNB for the gNB based on demand PRS. This is not good for the efficiency purpose of the on demand PRS.
2. For the gNB based on demand PRS, it is hard to solve the potential conflict that 2 similar PRS configurations from two neighbour gNBs are configured to a same gNB.
 |
| Intel | No | The coordination shall be done by LMF instead of gNB.  |

## 3.5 PRS Overhead reduction for UE Based Idle/Inactive Mode Positioning

LMF is involved when the LCS client is external; but when the LCS client is internal within UE and when AD is provided via broadcast/OnDemand, there is no involvement of LMF (also captured in end to end delay latency).

There are two questions raised

1) In such case, how would LMF authorize which mode the UE should operate in? The question is relevant for on demand PRS because the deployment may only grant UE-A when it needs to perform PRS overhead reduction (for ex: when there are few users performing positioning). Based upon UE measurement, LMF would be aware which PRS resources are contributing and which are not. But this feature would be missing when LMF is not involved; i.e the deployment may not have the option to authorize certain positioning mode (i.e UE-A) and obtain necessary measurements for the optimization of PRS overhead.

2) For PRS overhead reduction, as discussed above, UE measurement report is needed. How shall UE measurement be obtained when UE happens to be operating in UE based mode.

**Companies are invited to provide their views on these questions**

**1) How should the Positioning mode be decided for scenario where there may not be LMF involvement?**

**2) How is the SID objective “PRS overhead reduction” possible for scenario where majority of UE operates in UE based mode; i.e without measurement report/feedback?**

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| --- | --- | --- |
| Company | Answer 1 | Answer 2 |
| Huawei/Hisilicon | Not sure if this question is relevant for on-demand PRS. Could the rapporteur clarify why? | We think it is still possible if the UE sends on-demand PRS request in INACTIVE. The demand of the UE can be reflected with the on-demand PRS request without the measurement report/feedback. But in general, we think reporting the PRS measurement is helpful for the management of PRS transmission in gNB and LMF.  |
| OPPO | Similar question as Huawei, not sure about either the question itself or the relationship with on-demand PRS.. | The work on NR positioning for RRC\_INACTIVE state should be able to address the concern, where the LPP-based UE request can be delivered to LMF as well. |
| Qualcomm | Not sure how this question is related to on-demand PRS, but if the client is in the UE, the positioning mode (and potentially positioning method) is decided by the UE.  | The MO-LR option for response 3.2 solves that problem. In fact, a UE could indicate in an MO-LR (e.g. in an LPP request in the MO-LR) the needed duration of increased DL PRS. Then the UE can support UE based mode in RRC IDLE or RRC INACTIVE state without further network signaling. |
| CATT | Share the same view. The question needs to be clarified further. | In UE-based mode, UE still may request suitable PRS configured with UE-initiated request for on-demand PRS. |
| Xiaomi | If there are few users performing positioning, the PRS reduction can be performed by network without UE measurement reports, and then if the PRS configurations can’t satisfy the UE requirements, the UE can perform on-demand PRS. | If there are few users performing positioning, the PRS reduction can be performed by network without UE measurement reports, and then if the PRS configurations can’t satisfy the UE requirements, the UE can perform on-demand PRS. |
| Ericsson | Our view is that cell specific positioning mode should be considered rather than UE specific.To address Xiaomi: Positioning measurements are based upon distant TRP transmitting PRS and not only serving or neighbor cell based TRPs; in such case without measurements, it is not that easy to identify which TRPs and which beams associated with those TRPs are contributing. | RAN2 need to identify mechanism where UE would provide measurement report/feedback even when operating in UE based mode in order to reduce PRS overhead. |
| ZTE | From the network efficiency perspective, this may be based on the LMF configuration. Although a UE performs UE-based positioning service, LMF may be able to request the UE to upload the measurement reports,  | <= Please check answer 1. |
| Intel | On demand PRS can be used for latency reduction, network efficient and accuracy. For UE based positioning, there is still LPP message, and the UE may still request/indicate on demand PRS to the network.  | See answer 1.  |

## 3.6 Other

**Companies are invited to provide their view if any aspects missed to be discussed**

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| --- | --- |
| Company | Comments |
| Ericsson | Geometry plays a key role for accurate positioning. There may be multiple TRPs per cell; which TRPs are contributing with best GDOP info could help NW to select TRPs for DL PRS transmission especially for DL TDOA procedure.UE should provide GDOP based measurement result  |
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|  |  |
|  |  |

# Conclusion

To be provide later

# References

1. R1-2009842, TR 38.857 Study on NR Positioning Enhancements