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]
 |
| 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.  |
| InterDigital | all | The following benefits of On-demand PRS can be applicable for DL, UL and UL+DL positioning methods and for both UE-initiated and LMF-initiated on-demand PRS:Accuracy: On-demand PRS enables PRS configuration to be updated based on conditions at UE (e.g. radio environment) and measurements made by UE/network for improving positioning accuracy. Latency: On-demand PRS enables to minimize/eliminate additional latency associated with signaling/procedure for reconfiguration of PRS configuration. For example, PRS configuration may be dynamically activated/deactivated with low latency with on-demand PRS.Network/UE efficiency: On-demand PRS enables certain components of PRS configuration (e.g. resource, resource set, beams) to be dynamically updated for realizing the following:* Minimize overhead/resource wastage (e.g. at network by reducing the PRS resource/beam usage),
* Improve power savings (e.g. at UE for not having to measure/transmit over high number of resources/beams).
 |
| Apple | Accuracy, Latency, network efficiency | Similar to On demand SI in connected mode, On-demand PRS only helps to reduce network efficiency, not UE efficiency, as PRS is not transmitted by UE. |
| Nokia | EfficiencyAccuracyLatency | We agree with other companies views as to the objectives of using an on-demand PRS mechanism. This mechanism should allow to avoid unnecessary PRS transmissions, should allow dynamic control of PRS transmission attributes depending on some criteria. Solution should have some feedback loop from UEs and allow either gNB or LMF to control the number of PRS transmitting sources and the PRS transmission attributes. On-demand PRS avoids excessive beam sweeping in all directions, thereby reducing the latency on measurement and reporting. |
| Lenovo, Motorola Mobility | All | Enhanced accuracy, latency reduction, improved network & UE efficiency are the key benefits that can be realized through the introduction of On-demand PRS. From a network perspective, DL-PRS beam-based transmissions, which are not relevant for the calculation of the UE’s location estimate can be avoided, thus reducing NW overhead. On-demand PRS can also further enable the UE/LMF to meet a lower positioning latency budget and higher accuracy requirements via appropriate dynamic triggered requests and configurations.  |
| Convida | All | An On-demand PRS enhancement can enable efficient use of network resources, improved accuracy, efficiency and latency reduction as more PRS resources can be dedicated to a UE. |

Summary for Question 3-1:

13 companies provided their view on the objective, what should “on Demand PRS” aim to fulfil. 12 companies expressed that On Demand PRS can be useful for Network Efficiency, Accuracy Improvement and Latency Reduction and one company on Network efficiency.

1. RAN2 to capture in TR that RAN2 see benefits of “On demand PRS” Functionality.

## 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.
 |
| InterDigital | Option b and Option a (with comments) | For Option b, the on-demand request sent by UE to LMF (via LPP) can be used for changing the PRS configuration (e.g. resource parameters, muting pattern) as well as for coordinating the PRS transmission from different TRP/gNB (e.g. turning on/off). In this regard, it may be important to identify how and what the UE can send in the on-demand request for realizing the benefits associated with high efficiency and low latency. For Option a, we think the procedure can be generalized to be applicable also for RRC connected mode. In this case, the gNB which receives the on-demand request sent by the UE can either i) inform the LMF for changing the PRS configuration or ii) trigger a PRS configuration preconfigured by LMF.  |
| Apple | Option b | On-demand PRS only used in RRC\_CONNECTED with an active LPP session. |
| Nokia | See comment | We should prioritize the scenario of connected state UEs with LPP session and is involved in UE positioning to focus on the objectives of efficiency, accuracy and latency. This is in-line with Option b but the exact signaling detail needs further discussion. Idle/Inactive UE positioning is a new area that is also being studied under this same study item. We need to see how the solutions for Idle/Inactive UE positioning evolves before addressing that scenario also. As to what the objectives are of the UE-Initiated Request for on-demand PRS, it is the same irrespective of whether it is UE initiated or network initiated or what the RRC state is. With regards to the specific PRS parameters or attributes that can be controlled, it is too early to tell since we need to see what RAN1 agrees to for on-demand PRS. RAN2 can focus on the signaling procedure but wait for RAN1 to decide on the specific solution for the control of the PRS transmissions. |
| Lenovo, Motorola Mobility | Option b | Option b enables the UE to request the desired DL-PRS configuration according to its positioning KPI requirements while for Option a, the limiting factor in obtaining the desired DL-PRS configuration (including physical layer configuration parameters) may be the preamble message size.  |
| Convida | Option B prioritized | As others have pointed out, option A requires a significant amount of signalling to be defined. We propose option B, within an LPP session as the preferred approach. |

Summary for Question 3-2: On the objective of UE Initiated on Demand request for the two options

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

13 companies provided their response. 11 companies support option b. One of the companies support none. One of the companies support both.

However, the only company supporting option a) does not say it should be supported based upon Preamble request to trigger PRS transmission. But a request made during RRC connected state to a gNB and gNB should forward the trigger to LMF or provide pre-configured PRS configuration.

Rapporteur’s view is that instead of RRC+NRPPa; LPP can directly be used for UE-initiated request. Further, the preconfigured PRS configuration may not be simply based upon on the serving cell (TRP/gNB) which received the UE request but would be based upon multiple TRP/gNBs configuration and hence LMF co-ordination/initiation or Xn interchanges would anyway be needed.

1. RAN2 to provide recommendation for UE-initiated “on demand Request” during active LPP session

## 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 prioritized + option a secondary | 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.  |
| InterDigital | Both | We do not see significant differences between Option a and b, and, as indicated by Qualcomm, both can be supported with possible enhancements to NRPPa procedures. We also think it may be beneficial to support some related enhancements to LPP procedures such as dynamically varying PRS configuration applied at UE when triggered by LMF-initiated on-demand request. |
| Apple | Both | There is no fundamental difference between Option a and Option b |
| Nokia | Both | We see benefits in having both options a and b. These two options are essentially what we referred to in our past contribution as “dynamic PRS” and “on-demand PRS”, respectively. The benefit of Option a is dynamic optimization of PRS resources, in the sense that PRS resources can be increased in case of a local demand for higher accuracy (as an example). Benefit of Option b is higher spectrum efficiency by avoiding unnecessary transmissions of PRS to directions where there is no UEs to measure them. |
| Lenovo, Motorola Mobility | Option A and Option B | The LMF-initiated request can lead to improved accuracy, reduced latency and better UE and network efficiency. Option A and B may have some overlapping aspects and are not necessarily mutually exclusive. |
| Convida | Both | We see benefits as far as resource efficiencies to both options A and B and suggest both options can be supported. |

Summary for Question 3-3: On the objective of LMF Initiated on Demand request for the two options

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

13 companies provided their response. 11 companies support both options and one of the companies support only option b and one of the companies do not view any difference between the two options.

1. RAN2 to provide recommendation for LMF Initiated on Demand request in order to be able to dynamically vary the PRS configuration and also for recommending turning on/off beams.
2. RAN2 during WI phase decides or takes assistance from RAN1 to identify which DL-PRS configuration parameters can be dynamically changed.

## 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.  |
| InterDigital | Yes | We share similar view with Qualcomm. Assuming some of the LMF functionality resides in RAN, it can be beneficial in terms of latency to support UE-initiated gNB-based on-demand PRS. Moreover, as indicated by Ericsson, possible enhancements to XnAP may be considered for coordinating PRS usage between gNBs when supporting gNB based on-demand PRS.  |
| Apple | No | We prefer the legacy LMF-based coordination scheme for this. |
| Nokia | No | If we go with the option where the LMF can control the PRS transmissions with either option a or option b as described in Section 3.4, such LMF functionality can also be allocated to gNB in the case of LMF located at gNB. Overall, we don’t see any reason why the PRS resource optimization process should be coordinated by the gNB over Xn. This is because PRS are typically transmitted by multiple neighboring cells, and LMF is already the entity coordinating it. |
| Lenovo, Motorola Mobility | Maybe  | Considering IIoT positioning scenarios, it may be further envisioned that the LMF may be collocated with the gNB or LMU is housed within the gNB where the aim is to also reduce network latency, the benefits of gNB-based on-demand PRS in such cases, needs to further be investigated. A collocated LMF with a gNB may solve the issue with respect to neighboring gNB coordination of PRS transmissions, provided that the geographic area is limited as in the case of an indoor factory scenario. |
| Convida | Yes/No | Similar to the Qualcomm comments, if the gNB supports some LMF functionality, gNB-based on-demand DL-PRS can be supported. If the gNB does not have LMF functionality, then only LMF-based on-demand DL-PRS should be supported. |

Summary for Question 3-4: On the objective of gNB based on demand PRS reconfiguration

13 companies provided their response. 8 companies do not want gNB based on demand PRS. 4 companies view is that it may be supported if LMF is co-located with gNB. One company wants to support gNB based on demand PRS configuration.

1. For existing NR architecture, gNB based dynamic PRS configuration is not supported.

## 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?**

|  |  |  |
| --- | --- | --- |
| 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.  |
| InterDigital | For improving efficiency by changing PRS configuration, the UE (in the case of MO-LR) may be pre-configured with certain triggering conditions for sending the on-demand PRS based on the measurements made at the UE. The gNB can subsequently indicate to LMF or coordinate over XnAP with other gNBs for changing the PRS configuration (e.g. beams/TRPs to be updated).  | Similar to our answer to Question 1, the UE in UE-based mode can send the on-demand PRS such that PRS overhead reduction can be achieved. |
| Apple | Not sure why this question is related to on-demand PRS | I think the goal of overhead reduction with on-demand PRS is opportunistic. It is reasonable that it does not provide improvements in certain scenarios.  |
| Nokia | Issues involved and the questions are not very clear. | Issues involved and the questions are not very clear. |
| Lenovo, Motorola Mobility | Not sure about the intention of the question, but the LMF is normally involved in UE-assisted and UE-based positioning procedures. Need clarification on the relation to on-demand PRS for UE-based positioning. On-demand PRS would also be applicable to UE-based positioning based on the request mentioned in Question 3.2. | See Answer 1 |
| Convida | Similar to existing methods, if there is no LMF involvement, the UE (LCS client) can decide the positioning mode (UE-based, assisted). As others have pointed out, we are unsure if/how this is specific to on-demand PRS. | “PRS overhead reduction” can be realized if the UE sends on-demand PRS configuration requests rather than the overhead of PRS always broadcasted. |

Summary for Question 3-5: On the objective of PRS overhead reduction for UE based Idle/Inactive Mode Positioning:

The main question to ask was that “When UE is autonomously performing DL PRS based Positioning in Idle/Inactive mode; how will NW know which TRP/beams are contributing and which TRP/beams are not contributing”. How to reduce PRS overhead in such case?

One company mentioned “For UE based positioning, there is still LPP message, and the UE may still request/indicate on demand PRS to the network.”

Rapporteur’s comment: Yes, but UE can also compute positioning without being LPP connected. Anyhow, for the case when there is LPP connection; UE along with the request for on demand PRS may also provide the measurement report (error/uncertainties); So, NW may learn which TRPs/beams are contributing and which are not. It would benefit for both UE and the NW.

Some other comments from other companies:

* “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,”
* “In general, we think reporting the PRS measurement is helpful for the management of PRS transmission in gNB and LMF.”

Rapporteur’s comment: Yes, RAN2 should identify ways so that LMF is able to request the UE operating in UE based to upload the measurement reports.

1. RAN2 during WI phase identifies ways for the LMF to be able to obtain measurement results from UE operating in UE based mode in order to support LMF-initiated on demand PRS.

## 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

Based on the discussion in the previous sections we propose the following:

[Proposal 1 RAN2 to capture in TR that RAN2 see benefits of “On demand PRS” Functionality.](#_Toc61465433)

[Proposal 2 RAN2 to provide recommendation for UE-initiated “on demand Request” during active LPP session](#_Toc61465434)

[Proposal 3 RAN2 to provide recommendation for LMF Initiated on Demand request in order to be able to dynamically vary the PRS configuration and also for recommending turning on/off beams.](#_Toc61465435)

[Proposal 4 RAN2 during WI phase decides or takes assistance from RAN1 to identify which DL-PRS configuration parameters can be dynamically changed.](#_Toc61465436)

[Proposal 5 For existing NR architecture, gNB based dynamic PRS configuration is not supported.](#_Toc61465437)

[Proposal 6 RAN2 during WI phase identifies ways for the LMF to be able to obtain measurement results from UE operating in UE based mode in order to support LMF-initiated on demand PRS.](#_Toc61465438)

# References

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