3GPP TSG-RAN WG2 Meeting #115-e R2-210xxxx

Online Meeting, Aug 9th – 27th 2021

**Agenda item: 8.11.4**

**Source: Ericsson**

**Title: [Post114-e][603][POS] Procedures and signalling for on-demand PRS (Ericsson)**

**Document for: Discussion and Agreement**

# 1 Introduction

This document is to kick off the following email discussion:

* [Post114-e][603][POS] Procedures and signalling for on-demand PRS (Ericsson)

 Scope: Progress the design of on-demand PRS:

* Stage 2 procedure for the on-demand PRS request and configuration (can consider P9 of R2-2106467)
* Triggering conditions (if any are to be specified) for UE-originated and LMF-originated DL-PRS request
* Need for signalling from the UE of explicit parameters defining a requested DL-PRS configuration
	+ Does not include definition of the parameters that could be requested

 Intended outcome: Report to next meeting

 Deadline: Long/(August 6th, 0900 UTC)

The agreements so far in this area have been provided in section 6 for reference/recap.

# 2 Contact Information

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# 3 Discussions

In this section, we attempt to gather input on discussions that were incomplete in the RAN2 #114e with regards to trigger conditions and need for explicit signalling [6].

## 3.1 Triggering Conditions

### 3.1.1 Triggering Conditions for UE

In previous meeting there were proposals from several companies suggesting to have a trigger condition and this was also captured in the summary document [6]:

* Define the triggering criteria for UE-initiated on-demand PRS, e.g., threshold for measurement quality, confidence level, etc., to provide a guideline for UE to determine an on-demand PRS request [1].
* The QoS in LPP RequestLocationInformation message can be used to trigger UE to send on-demand PRS request [2].
* Enable the LMF to request an activation/deactivation for the on-demand DL-PRS resources based on the UE measurements of configured DL-PRS resources [3].
* RAN2 to capture UE-initiated triggers based on at least positioning QoS requirements, measurement quality, change in radio conditions and UE assistance information in Stage 2 specifications. FFS how to include LMF-initiated triggers in Stage 2 text proposal [4].
* On demand PRS can be triggered to meet the required positioning service level.

Further, there was a proposal which was formulated as part of summary document [6]:

* Proposal: A UE may require criteria or event in order to trigger an on-demand DL-PRS request to the LMF. FFS Details of the on-demand DL-PRS trigger criteria.

**Question 1: Do companies agree with above Proposal: should on-demand PRS be possible to trigger from the UE based on defined events or criteria?**

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| --- | --- | --- |
| Company | Agree with Proposal Yes/No | Comments |
| Qualcomm | No; up to implementation | The criteria or event for triggering on-demand DL-PRS are internal to the UE and may depend on various factors. E.g., when an application residing in the UE requires a location, there may be no (or not sufficient) DL-PRS resources available; e.g., all gNBs located around the UE location may have the DL-PRS "turned-off". Obviously, this would trigger a request for DL-PRS. An application may have low latency requirements, and if DL-PRS is currently available with a periodicity of e.g. ~10 seconds, a UE may request a DL-PRS with shorter periodicity, etc. A UE may also have other means for computing a position (e.g., RAT-Independent) and therefore, an on-demand DL-PRS request may not be triggered if e.g., measurement quality etc. is not met. Instead, a UE may use a different positioning method. This seems unnecessary to specify and should be left to implementation.There is also no principle difference to a "normal" LPP Request Assistance Data, which is also triggered based on the UE needs. The LMF indicates in a LPP Provide Assistance Data whether additional assistance data can be requested or not. The same principles should apply for on-demand DL-PRS. I.e., as already agreed, the network may indicate which predefined DL-PRS configurations are available and can be requested by the UE when needed. |
| ZTE | No; up to implementation | We share the similar view as Qualcomm. Different UEs may have different positioning requirements including accuracy and latency requirements, may also use different positioning methods including RAT-independent positioning methods. It is hard to specify a unique criteria/event for such different UEs to trigger on-demand DL-PRS.  |
| OPPO | No  | Agree with Qualcomm and ZTE. The trigger of on-demand PRS can be left to UE implementation. UE can request a on-demand PRS when needed, i.e. for accuracy enhancement or power saving. |
| Apple | No | Same view as others – triggering should be left to implementation.  |
| CATT | No; up to implementation | Different UE may have different positioning requirements. Besides, on-demand PRS is not only to satisfy the positioning QoS requirement of UE, but also for network efficiency, i.e., UE may request to turn off some PRS transmission even when the positioning QoS requirement is satisfied. Thus, a unified event or criteria is not appropriate.As for how to control the UE initiated on-demand PRS by NW, LMF can determine whether the UE is allowed to initiate the on-demand PRS, i.e., only UEs who received the available DL-PRS can be allowed to initiate the on-demand PRS. |
| Huawei, HiSIlicon | No | The mechanism of LPP procedure seems a bit different from the other spec that there is no formal definition for when the UE should send an LPP message, since it can be either solicited or un-solicited. We agree with qualcomm that we should leave this to UE implementation to align with the legacy spec. .  |
| Convida | Yes; specific UE behaviour left to implementation | Per our contribution at RAN2#114e, R2-2106379 [13], we support the proposal that the framework for on-demand PRS procedures should support triggering of an on-demand DL-PRS request to the LMF by the UE based on event(s) and/or criteria. The specific details of UE behaviors can be left to implementation. As it has been noted during initial RAN2 discussions, a UE-initiated mechanism for on-demand PRS is enabled by the UE triggering a request to the LMF. This assumes that the LMF is ultimately the control point for the on-demand requests and PRS transmission changes. Based on this assumption, procedures should enable a UE to be (pre-)configured by the LMF/network with some trigger to determine if/how existing DL-PRS can be requested for modification with a UE-initiated on-demand PRS request. This would aid the UE as to if/when and how to evaluate DL-PRS configuration. This trigger could be based on an event as simple as a position request from an application or allowed/not allowed criteria, but we need not define the implementation details as others have mentioned. |
| Xiaomi | No | When and why to trigger on-demand PRS can be left to UE implementation, for instance, UE can trigger on-demand PRS when the QoS requirements are not met based on UE implementation.  |
| Ericsson | Yes | We think the on-demand aspect are different than the normal LPP request. For the normal LPP request the resources can be considered constant. However, now we are talking about on-demand aspects.Even for the case as discussed in section 4. There is posSI with possible DL-PRS configuration. If UE has to make a new request for step 2; should not it be based upon the need that current DL-PRS config is not enough or more than enough and hence turn off some resources.1. Possible on-demand DL-PRS configuration provisioning (posSI);2. LCS Service Request; either the UE sends an MO-LR Request for on-demand DL-PRS; or some entity in the 5GC (e.g. GMLC) requests some location service; or the serving AMF for a target UE determines the need for some location service.3. Nlmf\_Location\_DetermineLocationRequest; content depends on Step 14. Possible LPP procedures; e.g., obtain UE DL-PRS capabilities5. LMF determines new DL-PRS configuration based on the request from Step 3.6. NRPPa on-demand DL-PRS reconfiguration procedure7. LPP procedures; LPP Provide Assistance Data message to provide the new DL-PRS configuration to the UE 8. Nlmf\_Location\_DetermineLocationResponse Content depends on Step 29. LCS Service Response10. NRPPa on-demand DL-PRS reconfiguration procedure; possible switch-back to original DL-PRS configurationThe risk of not having any fixed rules for requesting this on-demand PRS may cause UE to always request for the greatest and best config which may involve more PRS overhead constraint on the NW side.Hence, a simple rule could be that with the available PRS, if UE is unable to meet its Positioning QoS; it may request for additional PRS resources or different index. |
| InterDigital | Yes | On-demand PRS can be triggered by the UE based on detection of configured events or triggering conditions at the UE. Configuration of the triggering conditions (e.g. measurement quality) in UE would be beneficial to ensure that the UE only sends the on-demand PRS to request for certain DL-PRS configurations preconfigured by the network. In addition, the LMF will be aware of the motivation for the UE’s request and possibly prioritize the UE’s request based on the UE’s need (this may be LMF implementation). Otherwise, the LMF may be overwhelmed with multiple on-demand PRS requests from the same UE or different UEs. Realizing the benefits of on-demand PRS (e.g. latency reduction) would require defining triggering conditions and some rules to map between the triggering conditions and the DL-PRS pre-configurations allowed by network. For example, this mapping rule can be configured and used by the UE for indicating the PRS pre-configuration in the on-demand PRS.  |
| Fraunhofer | No | We agreed in the last meeting that the network can signal predefined PRS configurations to the UE and the UE can select one to request.Triggering the on-demand PRS shall be done by the LMF and not by the UE. The UE shall report its measurements to the LMF, and the LMF shall trigger a certain configuration based on the measurements. Likewise, the UE shall receive an assistance data that signals an association between an always on DL-RS (for example Rel. 16 PRS) and an on-demand PRS. Based on measurement on the always on DL-PRS, the UE shall select a configuration of on-demand PRS to perform measurements on. If we look at Figure 1 of this discussion, the PRS B#8 and PRS B#4 seem to share the same beam. Likewise, PRS B#7 and PRS B#3 also share same beam. Let’s assume the periodicity of B#7 and B#8 are much higher than that of B4 and B3. This means, if the UE receives B#3 as strongest beam, then it proceeds to measure B#7 and if the UE receives B#4 as the strongest beam then it proceeds to measure B#8. Which of the on-demand PRS is triggered ON or OFF could be decided based on the measurement of “always on” PRS by the LMF. This could be beneficial in reducing unnecessary DL-PRS transmissions and at the same time allow UE to do faster reconfiguration directly.We do not agree that the UE should be able to flexibly choose UE-specific PRS configuration or be able to trigger these. |
| vivo | No | It’s the upper layer who decide to trigger the on-demand PRS. The events or criteria are up to implementation. |
| Intel | No | Agree with comments from Qualcomm and OPPO that there is no need to specify any additional triggering criteria based on QoS. The only condition should be that the UE can only send the request to the LMF if the LMF supports the on-demand PRS request feature. |
| Lenovo, Motorola Mobility | Yes | It should be possible for the UE to trigger on-demand PRS based on a set of criteria. Some of the triggered events are based on the given radio conditions experienced by the UE, e.g. beam-failure at the UE and not only QoS, and thus needs to be specified. Furthermore, lack of specification of the triggering criteria for UE-initiated on-demand PRS request may be inconsistent across UE implementations, which can cause an issue. In terms of scale, multiple varying UE implementations can result in undesired triggering of on-demand PRS request by many UEs, creating a request signalling overhead issue. |
| Nokia | Yes | We propose UE to request from a preconfigured list of possible PRS configurations, each associated with a specific QoS/radio condition. Thus, UE can trigger an on-demand PRS request when the associated configured conditions are met, e.g., accuracy going below requirement, increased path loss, etc. |
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### 3.1.2 Additional input for Triggering Conditions for UE

If the answer to the above Question 1 is Yes; then to get further progress, it would be good to get additional input.

Based upon above proposal, it appears it is mainly the below two.

1. Based upon measurements, if after measurement, the measurement Quality (uncertainties, error and confidence level) is not up to satisfactory level, below threshold
2. Positioning QoS requirement is not met

Above a) and b) would boil down to essentially same KPI. That is when positioning measurements is computed and location is estimated, the measurement quality and confidence level is obtained, and the results can be cross checked to see whether positioning QoS is met or not. Further, if there is any fluctuation in radio condition, it would be reflected in the positioning measurements results and also in terms of measurement quality and confidence level of the measurements.

Hence, the above options can be written based upon:

* The trigger condition to request on-demand PRS from UE (UE operating in UE-based Positioning mode) is based upon Measurements and measurement qualities (uncertainties, errors and confidence level) which leads to not meeting a positioning QoS**.** Implying the trigger is based upon positioning QoS.

**Question 2: Is the trigger condition based upon positioning QoS agreeable for UE-based positioning? If agreeable, this means that when UE’s positioning QoS is not fulfilled, UE may initiate request of on- demand PRS. Another way to view the question would be, why would UE initiate on-demand PRS while its required positioning QoS is met?**

*Note: For UE-Assisted, it is LMF which computes the location and verifies whether QoS is met or not. Hence, UE-Assisted should be part of LMF-triggered on-demand PRS.*

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| --- | --- | --- |
| Company | Agree with Trigger Condition Yes/No | Comments |
| Qualcomm | No | It seems the two options (a) and (b) define criteria after the event. A good implementation should know whether available DL-PRS is sufficient or not before starting performing the measurements. Certainly, if DL-PRS is currently turned off, or if DL-PRS is available with high periodicity and low bandwidth, etc. a UE should not waste time and resources when it is clear a priori that the available DL-PRS is not sufficient for the intended application. For borderline cases, where it is unclear whether additional DL-PRS is needed, a UE can take response time into account and, e.g., initiate on-demand DL-PRS only if the response time will allow this.Note also, a LMF may verify the QoS also for UE-based mode (not just for UE-assisted mode). |
| ZTE | No | On-demand PRS is not only to satisfy positioning QoS but also for other purpose, e.g. for PRS overhead reduction and network energy saving. In the latter case, even QoS is satisfied by the current PRS configuration, UE may also trigger on-demand PRS to request/recommend LMF/gNB reducing or turning off some PRS transmission.  |
| OPPO | No  |  |
| Apple | No | See above |
| CATT | No | It seems the procedure for UE to evaluate the positioning is a prerequisite for UE to initiate the on-demand PRS, which it is not necessary indeed. I.e., if there is not sufficient PRS resources for UE to measure, UE can directly initiate the on-demand PRS without extra procedure to calculate the positioning. Moreover, as ZTE proposed, the on-demand PRS is not to satisfy the QoS requirement but also for network efficiency improvement.  |
| Convida | Yes/No | From our perspective, the UE may be configured with trigger conditions. However, Positioning QoS requirements are not the only criteria and it is not necessarily only for UE-based positioning (UE-assisted mode can still have PRS requests). One sidenote to this is that the positioning QoS could be based on measurements, but could also be determined/impacted by other attributes, e.g., current DL-PRS configuration, requirements from the LCS client, whether or not the UE is authorized/allowed to perform a PRS on-demand request, etc. |
| Xiaomi | No | We agree the positioning QoS requirements can be used for on-demand PRS trigger, but it is not necessary to explicitly specify the trigger condition.  |
| Ericsson | Yes | To QC: For MT-LR (location delivered to Client) LMF will know. However, If UE just get assistance data (MO-LR, UE LCS client) then LMF will NOT know whether QoS is met or not.Our view to answer 3.1.2 is that: Especially if the PRS configs are grouped in different QoS framework, then to ensure that the request from UE is meaningful, it should be based upon some need or informing to NW for a possible reduction of PRS overhead.Otherwise, the UE may always ask for the best config that can be available and hence risk in PRS overhead reduction (energy consumption). Further, we may need to define other mechanisms such as prohibit timers etc. to restrict if QoS based trigger is not accepted. |
| InterDigital | Yes/No | We think the above question is valid regarding the triggering conditions. We also think the following can be considered:i) Triggering condition can be based on measurement quality (e.g. RSRP, RSTD, multipath) and evaluation of positioning QoS, although in many cases measurement quality related to radio conditions at UE alone would be sufficient for deciding to send on-demand PRS. While we agree that the positioning QoS is directly impacted by measurement quality, we think that the UE need not evaluate at all times the positioning QoS for deciding on whether to trigger on-demand PRS. ii) Triggering conditions should also be applicable to UE-assisted positioning instead of only UE-based. The reason is, even for UE-assisted mode the LMF-based approach for deciding on whether to send new PRS configurations based on the UE’s measurement report and evaluation of positioning QoS may result in high latency. Instead, for minimizing latency we think it is beneficial to configure in the UE certain criteria such as mapping rule between triggering conditions (e.g. measurement quality) detectable at UE and pre-configured PRS configurations. Such criteria/mapping rules can be commonly used for both UE-based and UE-assisted modes instead of having separate procedures. |
| Fraunhofer | Yes | For UE based positioning the triggering criteria would be an implementation issue. We assume the on-demand PRS Configuration is defined by the network and the network provides assistance data to the UE. Based on this AD, the UE can decide if additional on-demand PRS may help to enhance the positioning accuracy and make the request. If a UE requests on-demand PRS and the network is able to grant the request, the network shall also be able to deactivate such on-demand PRS itself with or without indication from the UE.The UE may switch from measuring one group of on-demand DL-PRS resources to measuring another group of on-demand DL-PRS measurements based on the measurement of always on DL-PRS they are associated with. We have described one example in Question 1. Another example is the DL-AoD scenario where the on-demand PRS could be DL-PRS with narrow beamwidth and the always on DL-PRS could be transmitted with wider beamwidth. The measurement on always on DL-PRS (wide beamwidth) could be used to downselect the set on-demand DL-PRS with narrower beamwidth. This means, the UE needs to measure a smaller number of on-demand DL-PRS and the network can also only transmit those DL-PRS (since the LMF makes the trigger request). |
| vivo | No | Different UE with the same configuration of PRS may achieve different QoS performance and whether a specific configuration of DL-PRS can fulfill the QoS is up to implementation. Therefore, no explicit trigger condition of on-demand PRS is needed. A smart UE will balance the QoS and power consumption by implementation.  |
| Intel | No | See comment above |
| Lenovo, Motorola Mobility | Yes | We agree that at least the measurement quality metrics mentioned should be a baseline for input triggering of UE-initiated on-demand PRS. In the case of beam-failure, the measurement quality/lack of measurement is impacted and as a result this implies that the positioning QoS cannot be met, e.g. latency, accuracy. So it would be useful to mention this aspect in the description as well. QoS triggering criteria can be left to the higher-layers but can also be included in the description. |
| Nokia | Yes | NW can provide set of PRS configurations to UEs each mapped to a specific positioning QoS. Thus, triggering would be mainly conditioned on whether positioning QoS is fulfilled. |
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### 3.1.3 Triggering Conditions for LMF

For UE-Assisted

LMF needs to serve multiple UEs and thus it needs to take into account the measurement qualities (uncertainties, errors, confidence level) from several UEs. It needs to determine whether positioning QoS is satisfied or not for multiple UEs involved in positioning whilst ensuring PRS transmission overhead is energy efficient. LMF should strive towards a resource efficient configuration (save power, PRS overhead reduction).

Thus, the same trigger that is applicable to UE-bases should be applicable to UE-assisted i.e Positioning QoS should be also be valid for LMF when LMF computes the positioning for UEs operating in UE-assisted positioning mode.

**Question 3: Do companies agree that the computed Positioning QoS and PRS overhead reductions (energy savings) are the trigger condition for LMF for UE-Assisted?**

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| --- | --- | --- |
| Company | Agree with Trigger Condition Yes/No | Comments |
| Qualcomm | No; up to implementation | The LMF should trigger on-demand PRS when needed. The need may depend on various factors and should be left to implementation (same as in Question 1). There is also no difference here between UE-assisted and UE-based modes. Whether DL-PRS is UE or LMF triggered depends on where the LCS Client resides, but not on the positioning method and mode. Note that LMF triggers are likely to be network and operator dependent as well as complex, making any standard definition unsuitable. |
| ZTE | No | It is hard to explicitly specify the triggering condition at LMF side as LMF should consider multiple UEs and multiple TRPs’ configuration, capabilities and requirements. For example, LMF may still not trigger on-demand PRS request to TRPs even though the QoS of a few UEs is not satisfied probably because super most of UEs have no requirements for QoS improvement. |
| OPPO | No  | Similar as UE side, LMF can request on-demand PRS when needed with considering multiple factors. We prefer to left the trigger to LMF implementation. |
| Apple | No | See above |
| CATT | No, up to implementation | For LMF initiated on-demand PRS, it has to coordinate among multiple UEs, and too much factors including the positioning QoS, PRS overhead need to be considered. Such unified trigger condition is not appropriate and limit the flexible of LMF. |
| Huawei, HiSilicon | No |  |
| Convida | No, but | Agree with QCOM that there shouldn’t be a difference in the trigger conditions based on positioning mode (UE-based or UE-assisted). In the end, the LMF will have to decide based on, e.g., Computed Positioning PRS and PRS overhead reductions are two possibilities, and other factors, when to allow for on-demand PRS reconfiguration. It also seems as though we are mixing the UE-initiated on-demand PRS and LMF-initiated on-demand PRS with UE-based and UE-assisted methods. In the case for Q3, we start to look at the LMF decision making process in granting the requests for PRS reconfiguration from a UE or are we looking at LMF-initiated PRS reconfig, or both cases? |
| Xiaomi | No | There are many issues should be considered when LMF triggers on-demand PRS, such as different on-demand PRS requests from multiple UE, different TRP may have different on-demand PRS capability, different positioning QoS for different UEs, so we think the trigger condition based on LMF implementation is much better. |
| Ericsson |  | We agree how LMF decides can be up to implementation |
| InterDigital | No | We have a similar understanding with other companies in that the triggering conditions for LMF can be left to implementation. While it is possible that the decision to update the PRS configurations provided to UEs can be based on positioning QoS, and others such PRS overhead reduction, energy efficiency, etc., this can be handled at the LMF transparently to the UE. In addition, the triggering conditions that may be applicable at LMF need not be the same as those applicable at UE since the LMF may need to consider other factors involving multiple UEs rather than optimizing the PRS configuration for only one UE. In the same reasoning, we also think that these triggering conditions at LMF can be agnostic to whether UE-based and UE-assisted mode is used.  |
| Fraunhofer | Yes; but not limited to | We agree that the LMF may request configuration from the NG-RAN node or it may trigger a certain configuration from the set of configurations available as on-demand PRS. The condition itself, however, may be implementation specific / deployment specific. We agree that the LMF should strive towards a resource efficient configuration. One way to do so is to trigger a configuration of on-demand PRS based on UE measurement. Also processing constraints at the UE may be taken into account. |
| vivo | No | The LMF may trigger the on-demand PRS based on the factors including the power consumption, the overhead of the PRS, the capabilities of itself, the capabilities of multiple TRPs and the QoS requirements of multiple UEs. Making any standard condition will limit the flexibility. |
| Intel | No | Same reasoning as above, i.e. it is not clear how to clearly specify all possible trigger conditions for LMF. Therefore, it seems much more reasonable to leave it to implementation. |
| Lenovo, Motorola Mobility | No | Triggers for LMF-initiated on-demand PRS requests can be left up to LMF implementation. |
| Nokia | No | Answered as No because the triggers listed in the question 3 are not the only ones that can be used. There could be also some other optimization targets that LMF can consider for triggering on-demand PRS. Typically, we do not specify network behavior which is usually left to network implementation. |
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For UE-Based

For UE-based, the trigger would come from the UE to request the change of PRS configurations. Hence, another trigger for LMF would be based upon request received from UEs operating in UE-based positioning mode.

**Question 4: Do companies agree that the on-demand request received from UEs operating in UE-based (QoS not met) and PRS overhead reductions are the trigger condition for on-demand PRS trigger from LMF?**

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| --- | --- | --- |
| Company | Agree with Trigger Condition Yes/No | Comments |
| Qualcomm | No; up to implementation | Same as Question 3. |
| ZTE | No  |  |
| OPPO | No  | LMF can trigger on-demand PRS based on its implementation. |
| Apple | No | See above |
| CATT | No, up to implementation |  |
| Huawei, HiSilicon | No |  |
| Convida | No | Per Q3, differentiation of the positioning mode should not have an impact on the trigger(s). The UE may evaluate the existing PRS resources and configuration, based on one or more of the following: Positioning KPIs (e.g., QoS, positioning accuracy, positioning latency, inter-cell interference), measurements, current PRS configuration, whether or not the UE is authorized to perform (re-)configuration request, etc. Then, if the UE identifies that the criteria for a PRS (re-)configuration request has been met, the UE generates and transmits an on-demand PRS (re)-configuration request, to the LMF. The LMF may grant, partially grant the request (e.g., only grant one or more PRS config parameters, or only a portion of the requested resources), or deny the request, but the LMF trigger conditions associated with the on-demand requests received from the UE should not have RAN2 specification impacts. |
| Xiaomi | No |  |
| Ericsson |  | We agree how LMF decides can be up to implementation |
| InterDigital | No | Same answer as Q3 |
| Fraunhofer | Yes, but not limited to | We agree that the PRS overhead reduction should be considered while addressing the on-demand request from individual UEs, but exactly how the LMF triggers should be left to implementation.  |
| vivo | No | See above |
| Intel | No | Same as in Q4 |
| Lenovo, Motorola Mobility | No | Similar response to Q4, where triggers for LMF-initiated on-demand PRS requests can be left up the LMF implementation irrespective of the type of positioning scheme, e.g. UE-based. |
| Nokia | No | Same comment as for Question 3. |
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## 3.2 Need of Explicit Signalling

When there are fewer UEs that need to be positioned, it may be possible to configure UE specific PRS [11]; i.e PRS parameters tuned/optimized to the UE needs; for example, the PRS BW, periodicity, PRS resources (including number of Frequency layer, TRPs, Resource sets and resources). It is possible to obtain feedback from UE on its preferred configuration and also for LMF to reconfigure PRS parameters with dedicated signalling based upon some trigger conditions such as measurement quality/QoS. When the number of UEs scale, then instead of dedicated signalling rather a common broadcast which shall work for majority (or all) UE is preferred.

In FR2, the PRS might need to be transmitted in a beamformed fashion to compensate the higher path loss at higher carrier frequencies and therefore the beam sweeping procedures need to be followed, such as SS/PBCH, System Information (SI) or paging [10]. The PRS transmission to all beam sweeping directions results in an unnecessary transmission of PRSs. The UE may pop up in any corner of the beam and NW has to be opportunistic to identify the suitable TRPs/beams for the DL-PRS configurations. It may be difficult to broadcast beforehand or prepare the UE specific configuration beforehand.

There can be pre-configured DL-PRS configurations or there can be on demand explicit signaling. From the previous summary document, the intention is to get feedback on below proposal 1a.

**Proposal 1:** The on-demand DL-PRS request in an LPP Request Assistance Data message can include:

(a) explicit parameter defining a DL-PRS configuration (e.g., as defined by parameters in LPP IE *NR‑DL-PRS-AssistanceData*), or

(b) an identifier pointing to a pre-defined on-demand DL-PRS configuration.



Figure 1: Non-beamformed (left) and beamformed (right) PRS transmission [10]

**Question 5: Do companies agree with the need of explicit signalling to reconfigure DL-PRS parameters?**

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| --- | --- | --- |
| Company | Yes/No | Comments |
| Qualcomm |  | The question (and its relation to the introductory text) is not quite clear. There is certainly (explicit) signalling needed to reconfigure DL-PRS parameters, not just beam directions. |
| ZTE | Yes | Explicit signaling is needed definitely based on previous agreement. What is the new of this question should be clarified.  |
| OPPO |  | We agree with the intention of explicit signaling, i.e. reduce the overheads of unnecessary DL-PRS transmission. while as mentioned above, UE may pop up in any corner of the beam, we wonder how much gain can be achieved by this explicit signaling.And whether the DL-PRS parameters can be reconfigured based on UE’s explicit signaling depends on RAN1. We should wait for RAN1’s LS reply first. |
| Apple |  | Agree with QCOM – “some” signaling for sure will be needed, but not necessarily the kind implied in this question.  |
| CATT |  | The question is not clear, need further clarification |
| Convida | Yes | Some form of explicit signalling is needed to reconfigure DL-PRS parameters. |
| Xiaomi |  | We think the UE specific PRS configuration can be considered for on-demand PRS and the PRS configuration should be signaled to UE explicitly, but we are not clear on the intention of the question.  |
| Ericsson | Yes | There can be pre-configured DL-PRS configurations or there can be on demand explicit signaling. We see value in explicit re-configuration of DL-PRS parameters |
| InterDigital |  | We think that explicit signaling containing finer granular indication (e.g. beam ID/TRP ID) is needed for reconfiguring PRS. The explicit signaling would be applicable in the case of UE sending some indications (e.g. PRS parameters) to LMF and in response, LMF sending signaling to TRP/gNBs (e.g. in NRPPa signaling) that results in reconfiguring the DL-PRS.  |
| Fraunhofer | Yes | We differentiate between two cases, First: where the on-demand PRS has no bearing to an associated PRS. In the second case, if the UE is allowed to ask for full flexible parameter change, then this could be challenging for the LMF and NG-RAN to handle. Second, one or only a small subset of parameters are changed compared to an associated PRS. This associated PRS could be a DL-PRS (Rel. 16). Now, by on demand, the UE may be able to ask: 1. Change in update rate.
2. Change in different beam directions or beam characteristics

The association between two DL-PRSs (e.g. Rel. 16 DL-PRS) and one or more resources on-demand PRS may be used to signal the common configuration, and the configuration unique to a resource may be signaled explicitly. |
| vivo | Yes with comments | Including some explicit parameter in the on-demand PRS configuration may increase the flexibility. However, to ensure the LMF can handle the requests from multiple UEs, we think only a subset of parameters in LPP IE *NR‑DL-PRS-AssistanceData* can be on-demand.The subset of parameters may rely on RAN1 decision. |
| Intel | Maybe | The LMF should be able to change the DL-PRS configuration based on the request from UE or other events observed by the LMF itself. While it is certainly useful to have explicit signaling, we are not quite sure about the intention of the question beyond that and what was already agreed in the last meeting… |
| Lenovo, Motorola Mobility | Yes  | This is already in alignment with the discussions that DL-PRS configuration parameters to be updated can be explicitly signalled in the request signalling. |
| Nokia |  | I have to agree with QC that the question was not clear. The additional clarifications by the rapporteur that the question is about need for UE to explicitly signal the required PRS configuration parameters when initiating the on-demand PRS request helps but the question itself is still not phrased well. Our preference is to use pre-defined PRS configuration and let UE choose the pre-defined PRS configuration index to signal the request for on-demand PRS. |
|  |  |  |

# 4 Stage 2 Procedures

In this section, we attempt to come with an overall on-demand PRS procedure. In order to ascertain the stage 2 procedure, there are few questioners that require input.

## 4.1 On-Demand PRS

The On-demand PRS involves two scenarios which were also briefly touched upon during online session

1. On-demand PRS implies configuring PRS on need basis. This would also imply that there is no PRS being transmitted or PRS has been deactivated. If LCS client request for Positioning (GMLC, UE LCS client), the LMF needs to determine the suitable PRS configuration.
2. Another scenario is where PRS is already being transmitted and either the UE may request or LMF may need to change the current configuration

### 4.1.1 PRS is currently not transmitted

From a UE perspective, scenario a) is equivalent to a situation that already happens in real LTE PRS deployments: When PRS is being transmitted but LMF is unsure about the TRPs/Cells to be included in the assistance data. Thus, E-CID is considered as a pre-requisite procedure to provide LMF such information. For on-demand PRS, it may happen that the PRS is not currently being transmitted and based upon pre-requisite procedure such as E-CID (SSB and CSI-RS RSRP [7]) results, the LMF may request to gNBs for the initiation of DL-PRS transmissions.

Additionally, on-demand request is used to activate PRS which were potentially deactivated, this request/feedback should not be based on DL PRS reference signal but based on some other reference signal information. The simplest approach is that UE provides RSRP feedback per TRP per beam (e.g., SSB), which the network utilizes to switch ON DL-PRS [7].



1. The AMF transfers the location services request to an LMF which was received from an LCS client either in GMLC or in UE. If the LCS client is in UE, it may include measurement report (CSI-RS and SSB RSRP, E-CID report) as part of MO-LR request message [9]. The LCS client in UE may also provide other details such as number of TRPs, beam direction, start time and duration for the DL-PRS transmission which may also be forwarded from AMF to LMF [9].

Note: Positioning QoS is already part of LCS service request. (TS 38.305, 7.3.2)

1. If the client is GMLC or the measurements not available in step 1, the LMF may request for measurements to UE.
2. The UE provides the requested measurements to LMF, if not already provided in step 1.
3. LMF determines the needed DL-PRS transmission resources.
4. LMF request for DL-PRS transmission from different gNBs (TRPs) which may include serving and other TRPs.
5. The gNBs provide an acknowledgement to the LMF for initiating the PRS transmission; or may indicate failure if unable to initiate PRS transmission.
6. In case of success, the LMF prepares the DL-PRS configuration accordingly and provides to the UE.

Editor’s Note: The steps are mere suggestion based upon contribution of various companies during previous meetings and companies are requested to provide comments below.

**Question 6: Do companies agree on a high level with the above steps?**

|  |  |  |
| --- | --- | --- |
| Company | agree with above Yes/No | Comments |
| Qualcomm | No | The on-demand DL-PRS procedures do not need to differentiate between "PRS is currently not transmitted" (4.1.1) and "PRS is already transmitted" (4.1.2). The procedures are the same in both cases.The Stage 2 overall procedure for on-demand DL-PRS should show the following steps:1. Possible on-demand DL-PRS configuration provisioning (posSI);2. LCS Service Request; either the UE sends an MO-LR Request for on-demand DL-PRS; or some entity in the 5GC (e.g. GMLC) requests some location service; or the serving AMF for a target UE determines the need for some location service.3. Nlmf\_Location\_DetermineLocationRequest; content depends on Step 14. Possible LPP procedures; e.g., obtain UE DL-PRS capabilities5. LMF determines new DL-PRS configuration based on the request from Step 3.6. NRPPa on-demand DL-PRS reconfiguration procedure7. LPP procedures; LPP Provide Assistance Data message to provide the new DL-PRS configuration to the UE 8. Nlmf\_Location\_DetermineLocationResponse Content depends on Step 29. LCS Service Response10. NRPPa on-demand DL-PRS reconfiguration procedure; possible switch-back to original DL-PRS configurationNote that an LMF could request ECID RSRP measurements as part of step 4 in order to assist step 5, but there seems no need to include this in stage 2, except possibly in a note, since use of ECID (or another low latency position method) as a prelude to more accurate positioning is already enabled in Rel-16 for both 4G and 5G. |
| ZTE | No  | We think there is no need to differentiate the cases with and without PRS transmission. Further, we don’t need to list all existing steps especially ones irrelevant with on-demand PRS in the procedure. Our suggestion is to simplify the procedure as follows1. Possible on-demand PRS configuration provisioning (posSI)
2. Possible UE-initiated PRS request via LPP
3. LMF determines new PRS configuration based on the request from step 2
4. NRPPa on-demand DL-PRS request from LMF
5. NRPPa on-demand DL-PRS response from TRPs
6. LPP Provides Assistance Data message to provide the new DL-PRS configuration

to the UE |
| OPPO | No  | We see no need to differentiate the two cases in section 4.1.1 and 4.1.2. we prefer to simplify the procedure and ZTE’s suggestion is fine for us. |
| Apple |  | Agree with others that we need a single call flow for both cases. |
| CATT | No | There is no need to differentiate these two cases, i.e., w/o PRS transmission, common stage 2 procedures can be enough (procedures irrelevant of on-demand PRS are ignored):Step1: possible available DL-PRS provided by LMF(posSI or dedicated LPP);Step 2: possible may decide to initiate the on-demand PRS request via dedicated LPP based on the available DL-PRS resources;Step3: LMF determine new PRS configuration either **based on the request of step 2 or based on the implementation in LMF**;Step4: LMF initiate on-demand PRS request to NG-RAN;Step 5: NG-RAN feedback the on-demand PRS response to LMF;Step 6: LMF feedback the on-demand PRS response to UE, which may include the updated DL-PRS configuration, or ACK/NACK indication. |
| Huawei, HiSilicon | No | A general description of UE-based on-demand PRS request and network-based on-demand PRS request is needed and the stage2 procedure for the above two can be integrated into one single signalling flow. On top of the stage2 description provided by QC above, in step5, The following procedure should be added.UE determines new DL-PRS configuration based on the on-demand PRS configuration provisioning in step1 and send LPP message RequestAssistanceData to the network.  |
| Convida | Some enhancements | Agree with some of the other comments that we should have a single signaling flow. Some of the enhancements below can be left to implementation, but shown for completeness [13]. Also note that “perform measurements” could be as simple as the UE determining existing PRS configuration. |
| Xiaomi | No | We share the same view with other companies that we need a single call flow for the two cases in section 4.1.1 and 4.1.2. The following procedures can be considered:1 LMF acquires the on-demand PRS capability and supported on-demand PRS configuration of TRP via NRPPa message2 LMF provides on-demand PRS configuration via Pos sib or LPP provide assistance data message3 UE sends on-demand PRS request via LPP request assistance data message;4. LMF decides the new PRS configuration based on step 3 or LMF implementation;5. LMF sends on-demand PRS request to TRPs;6. TRP feedbacks the on-demand PRS response to LMF;7. LMF provide the new PRS configuration to UE via Pos sib or LPP provide assistance data message |
| Ericsson |  | The intention is to have a combined flow; but to get the necessary input so it can be later combined. |
| InterDigital | No | We do not think that defining a separate procedure specifically for the scenario where PRS is currently not transmitted would be necessary given that the support is already available in Rel-16 (e.g. E-CID based initial measurements) for assisting LMF to determine the PRS configurations.  |
| vivo | No | We also think there is no need to differentiate these two cases and the preferred stage 2 procedures is as follows:**Step 0: LMF decides the possible available on-demand DL-PRS based on the available DL-PRS resources and gNB capabilities.**Step 1: possible available on-demand DL-PRS provided by LMF (posSI or dedicated LPP);Step 2: possible LPP procedures to initiate the on-demand PRS request;Step 3: LMF determine new PRS configuration;Step 4: LMF initiate on-demand PRS request to NG-RAN;Step 5: NG-RAN feedback the on-demand PRS response to LMF;Step 6: LMF send the updated PRS configuration to UE. |
| Intel | No (see comment) | Agree with the comments above that it is not necessary to consider the two cases in 4.1.1 and 4.1.2 separately, since the determination of suitable PRS and whether to update the PRS configuration by the LMF needs to happen in both cases.As far as the steps go, we are fine with Xiaomi’s proposed ones as baseline |
| Lenovo, Motorola Mobility | No but | Agree that there needs to be a pre-requisite step for the LMF to roughly determine the location of the UE, e.g via E-CID, to know which beams carrying DL-PRS to switch on or off via Steps 2 and 3. However, it is beneficial if a general description/call flow can be included that covers both cases, i.e. 4.1.1 and 4.1.2, rather than describing them separately.  |
| Nokia | No | Steps 2 and 3 in Figure above reflect the request and collection of UE feedback for on-demand PRS. Since existing positioning related measurements (PRS, SSB or CSI based measurements) can be reused we could avoid an explicit request/response for measurements and reuse the existing LPP procedures. So, the steps listed by Qualcomm might work well. |
|  |  |  |

### 4.1.2 PRS is already transmitted

In this case, the assumption is that when the LCS client wants to position the UE; the DL-PRS is already being transmitted. RAN2 has already agreed that there can be multiple pre-defined configurations and UE may request one of the pre-defined configurations. Further, LMF may also change the current configuration with a different pre-defined configuration.



1. LMF provides Assistance Data (DL PRS configuration) to the UE via LPP dedicated signalling.

1a. Alternatively, or in addition to step 1, DL PRS configuration is provided to UE via RRC broadcast (posSIBs).

1. UE performs positioning measurements based upon received DL PRS Configurations from either LPP or RRC broadcast. If UE is operating in UE-based positioning mode and certain condition such as Positioning QoS is not met, the UE initiates On-demand PRS request.
2. UE sends an on-Demand PRS request with its preferred configuration such as configuration index or request to increase resource/decrease DL-PRS resources.
3. LMF determines whether there is need to change DL-PRS configuration. The LMF may decide based upon input received from multiple UEs.
4. LMF requests the serving and non-serving gNBs/TRPs for changing the current DL-PRS configuration via NRPPa.
5. The gNBs/TRPs provide the DL-PRS transmission update in the NRPPa response message accordingly.
6. LMF provides the on-demand DL-PRS configuration to the UE via LPP.

7a. Alternatively, or in addition to step 7, LMF provides the on-demand DL-PRS configuration to the gNBs via NRPPa for broadcast.

7b. gNBs provide the configuration to the UE via RRC Broadcast

Editor’s Note: The steps are mere suggestion based upon contribution of various companies during previous meetings and companies are requested to provide comments below.

**Question 7: Do companies agree on a high level with the above steps?**

|  |  |  |
| --- | --- | --- |
| Company | agree with above Yes/No | Comments |
| Qualcomm | No | See our response to Question 6. |
| ZTE | No | See our response to Question 6 |
| OPPO | No  | See our response to Question 6 |
| Apple | No | See above |
| CATT | No | See our response to Question 6. |
| Huawei, HiSilicon | No |  |
| Convida | No | The procedure for PRS transmitted and PRS not transmitted can be the same. |
| Xiaomi | No | See our response to Question 6. |
| Ericsson |  | The intention is to have a combined flow; but to get the necessary input so it can be later combined. |
| InterDigital |  | We think that the order of the steps need not be strictly as those provided the 4.1.2 procedure. For example, in some implementation steps 5 – 6 can be performed beforehand (e.g. prior to step 1), e.g. before providing the PRS pre-configurations allowed by network in assistance data to the UE. This would enable step 7 to be either made optional or includes ACK/NACK response indicating whether the requested on-demand PRS is fulfilled.  |
| vivo | No | See above |
| Intel | No | See comments in response to Q6 |
| Lenovo, Motorola Mobility | No but | Similar response to Q6 on handling the two cases with a single call flow. In addition, we support that the triggering condition in Step 2 be captured in the Stage 2 description to deal with potential inconsistencies in how the DL-PRS is triggered. As a high-level suggestion, perhaps steps in 4.1.1 can be incorporated into the above 4.1.2 call flow. |
| Nokia | No | See our comments to Question 6. |
|  |  |  |

In order to describe the stage 2 procedure and to identify correct wordings; we would like to get some input from companies for the case when PRS is already being transmitted.

NW behaviour

When multiple PRS configurations have been defined and notified to UE, the request from UE may include the index of the pre-defined DL-PRS configuration. One question that arises and was also discussed briefly online as what should be the NW/LMF behaviour if it receives such request from UE?

1. Is LMF obliged to change the configuration even if it received request from just one UE?
2. Is UE request considered as preferred configuration from UE and it is up to NW implementation as when and how NW acts upon such request?
3. If several UEs request the same configuration index; then LMF may request gNBs to change the configuration.
4. It is anyway up to NW implementation

**Question 8: Companies are invited to provide input on which option is best suited here. Please select multiple options if necessary?**

|  |  |  |
| --- | --- | --- |
| Company | NW Behaviour Options | Comments |
| Qualcomm | None | As with any regular LPP Request Assistance Data, there can be a positive, partial positive, or failure outcome. (a) Positive outcome: The LMF is able to fulfill the request. LMF configures the DL-PRS and provides the configuration information in a LPP Provide Assistance Data message to the UE.(b) Partial positive outcome: The LMF is able to partially fulfill the request; e.g., select a DL-PRS configuration "similar" to the requested one or the same as the requested one but applied to only a small number of TRPs, and provides the configuration information in a LPP Provide Assistance Data message to the UE, including an indication that the requested DL-PRS configuration can currently not be completely provided (which, however, may be implicit).(c) Failure: The LMF is not able to fulfill the request and returns an error cause. |
| ZTE | b or d | LMF has to consider multiple UEs’ requests which is up to LMF implementation anyway |
| OPPO | d is preferred. | And UE always follow the latest assistance data provided by LMF. |
| Apple | Neither | I think we should discuss the signalling, not the LMF behavior (which won’t be standardized anyway). |
| CATT |  | Whether LMF can accept the on-demand PRS request from UE or not, there can be corresponding response from LMF, i.e., similar like current mechanism for LPP Request Assistance Data and LPP Provide Assistance Data procedure. (2) The LMF provides the requested assistance data in a LPP Provide Assistance Data message, if available at the LMF. The entire set of assistance data may be delivered in one or several LPP messages, e.g., one message per GNSS. In this case, this step may be repeated by the LMF several times. If any of the UE requested assistance data in step (1) are not provided in step 2, the UE shall assume that the requested assistance data are not supported, or currently not available at the LMF. If none of the UE requested assistance data in step (1) can be provided by the LMF, return any information that can be provided in an LPP message of type Provide Assistance Data which includes a cause indication for the not provided assistance data. |
| Huawei, HiSilicon | d) | It is up to the network’s own judgement whether to change fulfil the UE’s request based on multiple factors.  |
| Convida | Closest option b) | From [13], **LMF response to UE PRS (re-)configuration request.** The UE PRS transmission requests are received by the network and a response should be sent from the network/LMF:1. Update one or more TRP PRS configuration set (group of configurations) or resources
2. The network may grant, partially grant the request (e.g., only grant one or more PRS config parameters, or only a portion of the requested resources), or deny the request
 |
| Xiaomi | d  | It is up to network implementation, the LMF can provide the PRS configuration requested by UE, or provide new PRS configuration which is not requested by UE, or provide an indication to indicate UE to continue using the available PRS configuration.  |
| Ericsson | d |  |
| InterDigital | d | Whether the on-demand PRS request is fulfilled or not can be up to network implementation and multiple factors (e.g. new requests from multiple UEs, impacts on existing UEs) may impact the decision at the LMF. However, we also think that the LMF can control the pre-configurations provided to UE in assistance data at any time such that the possibility of UE sending an on-demand PRS which may end up not being fulfilled is minimized.  |
| Fraunhofer | b or d | It should be left to the NW to decide, but the response to the UE whether its request is fulfilled could be as QC suggested. |
| vivo | d | Up to implementation. |
| Intel | B | As with other “similar” scenarios, we assume that the indication from the UE for a specific DL-PRS configuration serves as an indication of preference and anyway it should be upto the LMF implementation how to proceed (considering various factors that need not be specified) |
| Lenovo, Motorola Mobility | B | In the context of this question, we would support a behavior that where the network receives a DL-PRS configuration recommendation by the UE and then it would be finally up to the network to decide on whether to consider the recommended request by the UE. If multiple PRS configurations have been defined and notified to the UE, isn’t it already assumed that the network can accommodate any of those provided PRS configurations to a certain extent, otherwise it would not have provided those configurations to the UE in the first place? |
| Nokia | d | Question is not very clear. Questions should be self-contained i.e. explicit and fully explain the issue for decision making. Based on the description provided above the question, it should be up to LMF implementation how it handles the request from a UE or requests from multiple UEs, that contain a pre-defined PRS configuration index. |
|  |  |  |

UE Behaviour 1

The different DL-PRS classification/configuration could be as suggested below [10].

*Table 1 – DL PRS pre-configuration associated with QoS and radio conditions*

|  |  |
| --- | --- |
| *QoS Requirement / Radio Condition* | *Pre-configured PRS Configuration* |
| ***A:*** *High-accuracy and low-latency positioning*  | ***#1:*** *a configuration with large bandwidth and short periodicity* |
| ***B:*** *Medium accuracy and latency positioning*  | ***#2:*** *a configuration with medium bandwidth and periodicity* |
| ***C:*** *Low-accuracy and high-latency positioning*  | ***#3:*** *a configuration with small bandwidth and large periodicity* |
| ***D:*** *Positioning with large UL/DL path loss* | ***#4:*** *a configuration with large power* |

The classification of DL-PRS configurations may be based upon above where one set of configuration contains low periodicity and high BW whereas another category may contain high periodicity and low BW.

Question 9: In such multiple-DL PRS configuration; how to ensure, UE is not always requesting configuration that is configured with lowest periodicity and highest BW? Example: If UE was provided with configuration C, how to ensure UE does not ask for configuration A when configuration B would have been sufficient for the UE?

|  |  |  |
| --- | --- | --- |
| Company | UE Behaviour 1 | Comments |
| Qualcomm |  | If the network advertises the available DL-PRS configurations to UEs, a UE should be able request any of the configurations possible/allowed. The NW controls the available DL-PRS configurations per agreement:"The network can signal predefined PRS configurations to the UE and the UE can select one to request."Another possibility is to allow a UE to indicate more than one configuration – e.g. in a priority order. That allows the network to select a configuration which will at least assist the UE. |
| ZTE | Up to UE implementation  | In our view, smart UEs will not request higher level of PRS configurations if a lower level of PRS configuration can satisfy its QoS. Thus, the design like Table 1 can be up to implementation.  |
| OPPO | Up to UE implementation | There is no need to limit UE on selecting which configuration. UE can select anyone among the configurations that pre-configured by LMF. |
| Apple |  | Should be left to UE and network implementation. |
| CATT |  | UE can select anyone among the available DL-PRS provided by LMF, since LMF can determine how much PRS configuration are required to satisfy the positioning QoS requirement of UE.  |
| Huawei, HiSilicon |  | It is up to the network implementation to decide which PRS configuration should be given to the UE after the UE PRS request. The network knows the QoS of the LCS request and will take that into consideration when processing the UE’s PRS request |
| Convida | UE configured with DL-PRS “request” criteria associated with multiple DL-PRS configurations | The LMF may configure a “Request PRS ReConfig Allowed” parameter for requests of multiple PRS configurations, consisting of one or more of the following aspects:1. Specific to a UE or group of UEs2. Associated with a serving cell/beam/area3. Counter limit (e.g., number of UE requests allowed)4. Validity/Time limit, and/or associated prohibit timer5. Service type, e.g., Emergency services6. QoS thresholdsSome or all of the above specifics can be part of a smart implementation, but from a protocol/procedure perspective, we can simply enable multiple configurations via LPP or PosSI to broadcast the gNB support/doesn’t support UE-initiated DL-PRS requests for configuration a, b,...,n. |
| Xiaomi | Up to UE implementation | UE can choose anyone among the PRS configurations provided by LMF, and the final decision will be made by LMF. |
| Ericsson |  | To Huawei: NW may know the needed QoS but may not know if UE QoS has been met or not for UE based and if the client is in UE.We agree with QC that some prioritized configuration can be provided. The prioritized configuration can be indicated from NW to UE. The NW may sort the pre-configuration indexes based upon the number of TRPs, resource sets, resources. An example with index 1 with lowest number of TRPs and index n with the maximum number of TRPs.Smart UE should ask for config with the lowest index that meets its QoS.  |
| InterDigital |  | We have a similar understanding with Qualcomm regarding the network allowed PRS configurations that are provided to the UE. To ensure that the UE appropriately indicates from the allowed PRS configurations, the LMF can provide to UE some rules/criteria which essentially indicate the mapping between the triggering conditions (e.g. measurements quality) detectable at UE and the allowed PRS configurations.  |
| Fraunhofer | Up to UE and network implementation | It may be worthwhile that the network evaluates requests from several UEs and selects a new configuration fulfilling the requirements of several UEs  |
| vivo | Up to UE implementation | Both of the pre-configured PRS configuration and the decision of UE are up to implementation. Meanwhile, no priority is needed. For example, there can be a configuration with large bandwidth and long periodicity and a configuration with small bandwidth and short periodicity. The UE may select one of them based on the data traffic, the QoS requirement and UE capability, which means the priority for different UEs may be different as well. |
| Intel | Up to UE implementation (see comment) | The question seems a bit strange; certainly, if the network provides the UE with a set of DL-PRS configurations, the UE should be free to select any of them. In any case, we assume the network is free to accept or reject the request from the UE |
| Lenovo, Motorola Mobility |  | We would also prefer that a UE provides a priority order of the desired PRS configurations to be most likely accepted by the network to best serve its own QoS requirements. In this way, if the network cannot accept the highest priority PRS configuration then it considers the next priority configuration on the list. This would imply that if the highest priority is not considered then the UE has less chances of fulfilling its positioning QoS, e.g. in the case of UE-based positioning. A network configured priority of DL-PRS configurations can be separately considered. |
| Nokia | Use of trigger conditions as discussed in Question 1 | “How to ensure UE is not always requesting configuration that is configured with lowest periodicity and highest BW”? UE should follow the standardized triggering criteria for the selection of appropriate PRS configuration index to signal to LMF. |
|  |  |  |

UE Behaviour 2

**Question 10: What happens if UE request is not fulfilled by LMF or LMF is unable to provide preferred configuration?**

Please indicate (also multiple) options and any comments.

1. Should UE request again after certain interval
2. (Pre) configured wait time by LMF
3. decided by UE
4. Should UE perform the measurement based upon the configuration that has been currently provided and not request further after one attempt/request?
5. Shall a NACK be required by UE from LMF incase if LMF is not able to fulfil?
6. Should UE log the request and upload it as part of SON reporting so NW can learn the UE preferred/desired configuration at a certain location if NW does not accept UE request.

|  |  |  |
| --- | --- | --- |
| Company | UE Behaviour 2 | Comments |
| Qualcomm |  | See our response to Question 8.This is similar to a "normal" LPP Request Assistance Data message. E.g., 38.305 specifies at multiple places:"If any of the UE requested assistance data in step (1) are not provided in step 2, the UE shall assume that the requested assistance data are not supported, or currently not available at the LMF. If none of the UE requested assistance data in step (1) can be provided by the LMF, return any information that can be provided in an LPP message of type Provide Assistance Data which includes a cause indication for the not provided assistance data." |
| ZTE |  | UE behavior is clear as 38.305 (Qualcomm pointed it out). No need further enhancement/discussion |
| OPPO | a + b | A prohibit timer can be started once on-demand PRS request is transmitted, and UE shall perform measurement based on the existing PRS config until new configuration is received.UE can re-send the on-demand PRS request if timer expires. |
| Apple |  | As we mentioned above, we can potentially discuss c), i.e. the signalling (this is not to say we support it, just to say it may be discussed). The rest should be left to implementation.  |
| CATT | Nothing or perhaps a)-1 | UE’s behavior is already specified in TS38.305, i.e., “If any of the UE requested assistance data in step (1) are not provided in step 2, the UE shall assume that the requested assistance data are not supported, or currently not available at the LMF.” Besides, some enhancement can be further discussed if majority agree, i.e., LMF to control the interval between two consecutive on-demand PRS request, i.e., (pre) configured wait time by LMF. |
| Huawei, HiSilicon | C | The network can send an “error” message to the UE that the request is not fulfilled |
| Convida | Similar to Q8. | UE should be configured with limitations associated with On-demand PRS requests. NW implementation can grant/partially grant or deny PRS requests. |
| Xiaomi | b | The UE behavior can be based on LMF feedback, if the requested PRS configuration can’t be met by LMF, the LMF can provide an indication to UE and then UE can continue to perform PRS measurement based on available PRS configuration.  |
| Ericsson | d | We do not see that it is same as existing procedure. As this is based upon finding a balance between PRS overhead and ensuring transmitted PRS meets QoS. Hence, we think at minimum UE may log its desired/preferred configurations and report it later for the NW to learn in order to serve the UE better without having to request.  |
| InterDigital | a, b, c | We think that similar to UE behavior for identifying PRS configuration to request (Question 7), the UE behavior when the LMF is unable to provide the indicated PRS configuration can be defined. For latency critical applications, the UE behavior when the on-demand request is not met needs to be defined. For example, the UE behavior as described by Oppo can include starting a prohibit timer and using the existing PRS configuration until a new PRS configuration is received or resending the on-demand PRS. |
| Fraunhofer | a, or c |  |
| vivo | a1+c  | If the UE requested assistance data cannot be provided by the LMF, return an LPP message includes a cause indication for not providing the assistance data and a timer. The UE can request for another on-demand PRS when the timer expires.  |
| Intel | Nothing (or maybe a1) | Based on Qualcomm’s comment, the UE behavior beyond just “assuming that the requested assistance data are not supported or currently not available at the LMF” should be just to follow existing specification and no need for further enhancement is seen.So, the main question is whether any additional UE behavior regarding the need to re-request the PRS configuration again needs to be allowed/specified. We are not fully sold on the usefulness of such optimizations, but if majority of companies wants to introduce it, we can be ok |
| Lenovo, Motorola Mobility |  | Agree with Qualcomm’s description. As Intel mentioned, procedures on re-triggering an on-demand PRS request after it has not been fulfilled remains needs to be clarified.  |
| Nokia |  | To avoid negotiations between the network and UE for on-demand PRS, which results in increased signaling and latency, the multiple on-demand PRS configurations that are pre-configured by LMF or the alternate on-demand PRS configurations that could be requested by UE can be sorted in order of preference by the LMF and UE respectively to increase the chances of LMF fulfilling the UE request.In addition, use of back-off timer or specification of a standard UE behavior as in the case of LocationMeasurementIndication procedure when requesting measurement gaps can be used. There must be some standardized behavior to contain the UE from indefinitely going on requesting a specific PRS configuration from LMF. |
|  |  |  |

UE Capability

There was also suggestion that on-demand PRS should have UE capability in contribution [12]. If so, what would be the UE behaviour if LMF wants to change the configuration based upon a request from some other UE? Assume that the current PRS configuration was requested by a first UE. A second UE requests another PRS configuration and LMF changes the configuration accordingly. In this case, what should be the behaviour of the first UE? One Option can be:

* On-demand PRS functionality is supported by default. The NW updates the essential changed PRS configuration parameters to each UE (either via broadcast or via dedicated signaling). The essential parameters that has been changed should be notified to UE and that should be discussed by RAN1.

**Question 11: Do companies agree that capability is needed? Further, please provide additional comments.**

|  |  |  |
| --- | --- | --- |
| Company | Capability is needed Yes/No | Comments |
| Qualcomm | Yes for any new DL-PRS Assistance Data | It is not clear what is meant by "on-demand DL-PRS capability", since on-demand DL-PRS would be a network feature, rather than a UE feature and the UE need to know whether the NW supports on-demand DL-PRS. However, a UE capability would be needed for any new DL-PRS assistance data, such as the new LPP assistance data IE which contains the set of possible on-demand DL-PRS configurations.On the introductory text to this question:A start time and a time duration for when and how long the requested DL-PRS configuration is required and provided (expiration time) should not require notifying UEs when the DL-PRS configuration is changed back again.UEs using existing DL-PRS need not be impacted by on demand DL-PRS from other UEs as long DL-PRS is increased without changing existing DL-PRS. This can also apply to subsequent on demand DL-PRS if later changes do not remove previous changes. |
| ZTE | Yes | Any new features should correspond to one **new UE capability**. From UE side, it has to report network if it supports receiving the Rel-17 new PRS assistance data for on-demand DL PRS configurations. |
| OPPO | Yes  | UE capability is need for a UE supporting on-demand PRS request based on its positioning requirement. And for the case mentioned above, we see no need to define a new capability. The most straightforward way is to follow the latest PRS configuration provided by LMF for both first UE and second UE.  |
| Apple | Yes | In general, “some” new UE capability will be needed, but not necessarily for this specific functionality. |
| CATT | Yes | UE should indicate its on-demand PRS capability to NW, so that NW can decide whether to provide the available DL-PRS to UE.  |
| Huawei, HiSilicon | Yes |  |
| Convida | Yes | A new capability is necessary for on-demand PRS reconfiguration support. |
| Xiaomi | Yes | A new UE capability will be needed for sending Rel17 LPP request assistance data message and receiving LPP provide assistance data message.  |
| Ericsson | Yes, however | We agree with QC that to ensure BW compatibility with previously transmitted DL PRS configurations NW need to ensure that:UEs using existing DL-PRS need not be impacted by on demand DL-PRS from other UEs as long DL-PRS is increased without changing existing DL-PRS. This can also apply to subsequent on demand DL-PRS if later changes do not remove previous changes.However, Assuming UE 1 was scheduled to perform measurements in beam A, B and C; UE 2 notified beam B is not needed rather beam D is needed. New config would be beam A, B C and D. For PRS overhead saving it would have been good to have beams A, C and D.But as A, B, C and D needs to be enabled; NW is unable to perform PRS overhead reduction.It would have been nice if UE can handle any missing PRS transmission previously indicated without any error. |
| InterDigital | Yes | We have similar views with those of Qualcomm and ZTE that the assistance information related to on-demand PRS configuration can be based on UE capability for supporting Rel-17 procedures/signaling. For other UEs, the existing Rel-16 procedures can be used where the LMF can send assistance data to UE in LPP message or SIB when updating any PRS configurations.  |
| Fraunhofer | Yes |  |
| vivo | Yes |  |
| Intel | Yes | We assume a new UE capability is needed to support the new LPP assistance data IE containing the set possible on-demand DL-PRS configurations. |
| Lenovo, Motorola Mobility | Yes |  |
| Nokia |  | Question is unclear. If existing measurements and PRS configuration parameters are used, we don’t see why a new UE capability is required. If RAN1 identifies any new parameters for on-demand PRS operation, then we can discuss later if a UE capability is required for that or not. |
|  |  |  |

Additional Assistance Data from UE

The trigger condition such as Positioning QoS or measurement quality and confidence may be impacted because of some factors such as some DL-PRS Resources belonging to certain PFL, TRP, Resource set may yield poor performance such as poor RSRP, NLOS, interference, poor GDOP, ranging errors etc. For DL-TDOA in Rel-16 before reasons have been provided as error causes from UE to LMF. In order for LMF to make wise decision, UE may provide additional assistance data.

Currently for NR-DL-TDOA positioning method of any error encountered during positioning then the UE provides below information to the LMF.

#### *NR-DL-TDOA-TargetDeviceErrorCauses*

The IE *NR-DL-TDOA-TargetDeviceErrorCauses* is used by the target device to provide NR DL-TDOA error reasons to the location server.

-- ASN1START

NR-DL-TDOA-TargetDeviceErrorCauses-r16 ::= SEQUENCE {

 cause-r16 ENUMERATED { undefined,

 assistance-data-missing,

 unableToMeasureAnyTRP,

 attemptedButUnableToMeasureSomeNeighbourTRPs,

 thereWereNotEnoughSignalsReceivedForUeBasedDL-TDOA,

 locationCalculationAssistanceDataMissing,

 ...

 },

 ...

}

-- ASN1STOP

The same scheme can be followed also for requesting new PRS configuration by UE.

-- ASN1START

PRS-ConfigurationRequestCauses ::= SEQUENCE {

 cause-r17 ENUMERATED { poor-RSRP,

 nlos-ReferenceTRP,

 nlos-MeasuredTRPs,

 poor-GDOP,

 rangingErrors,

 interference,

 ...

 },

 measurementTimestamp UTC

 ...

}

-- ASN1STOP

**Question 12: Do companies agree that additional assistance data is helpful? Further, please provide additional comments.**

|  |  |  |
| --- | --- | --- |
| Company | Additional Assistance data helpful: Yes/No | Comments |
| Qualcomm | No | This seems unrelated to on-demand DL-PRS.The target and server error causes are responses to a request; e.g., a LPP Request Location Information may result in a target device error cause in a LPP Provide Location Information. Similar, a LPP Request Assistance data may result in a server error cause in a LPP Provide Assistance Data. The proposed *PRS-ConfigurationRequestCauses* seem not error causes. |
| ZTE | No | This enhancement is unnecessary. The reason to request change of PRS configuration has been reflected in the UE initiated on-demand PRS request. For example, if UE requests a larger PRS power compared with the existing transmitting PRS, it implies poor RSRP of the existing PRS. Thus, the redundant functionality is not needed here. |
| OPPO | No  |  |
| Apple |  | We typically use the word “cause” in relation to an error, which is not what we discuss here. We are generally open to discuss “additional assistance information”, but then it would be good to understand how the network will use it. |
| CATT | No  | Seems like the work of SON/MDT?Although such enhancement may provide some assistance information for LMF to coordinate among multiple UEs and determine whether to accept the on-demand PRS request, but the benefit is negligible compared with the signaling overhead. Moreover, as ZTE’s comments, anyway the reason to request change of PRS configuration can be implicitly reflected in the UE initiated on-demand PRS request. |
| Huawei, HiSilicon | No |  |
| Convida | Yes | Some new assistance data could be helpful associated with a UE PRS on-demand request, and should be further studied. One or more of the following detected error sources and quantitative measures, but not exhaustive:* Multi-path and LOS/NLOS Identification for serving and neighbor cells
* Insufficient number of TRPs/gNBs for PRS-related positioning calculations, e.g., RTT, TDOA, AoD
* PRS intercell interference
 |
| Xiaomi | No | We share the same view that the reason to send on-demand PRS request can be reflected by the PRS configuration which UE is requested. |
| Ericsson | Yes | It is strange what ZTE says is that that UE can ask PRS with power boosting. Power boosting is up to NW and should not be indicated explicitly by UE.We agree with Convida that we can further be studied as how to convey such additional information. |
| InterDigital | No | We agree with the rapporteur that additional assistance data would be helpful at LMF. However, we think that on-demand PRS and the associated configurations (e.g. rules for triggering the request) would be adequate for indicating to LMF the presence of error sources and the PRS configuration to use for overcoming the error sources.  |
| Fraunhofer | Yes | Additional assistance data (provided by the UE is helpful, but the actual content is FFS). The UE may be able to associate, for example, movement state and others such as sensor measurements, to whether the provided on-demand PRS are providing good performance. Especially measurements would be more helpful here than “qualitative” feedback. |
| vivo | No | The trigger or cause of on demand PRS request from UE is up to UE implementation and no need to explicitly expose it to NW. |
| Intel | No | Agree with Xiaomi |
| Lenovo, Motorola Mobility | Yes but | The assistance information related to the measurements can be implicitly provided to the LMF via existing signalling by considering additional measurement metrics in the *ProvideLocationInformation* message which indicates the quality of the measurements, e.g. if a particular measurement is affected by LOS/NLOS. A new *PRS-ConfigurationRequestCauses* IE may therefore not be needed. |
| Nokia | Maybe | Question is unclear. Are we talking about UE indicating the reason for the initiated on-demand PRS request? Then, such information would be beneficial for LMF to be aware of the underlying need for a new configuration. LMF could also use this information collected over time to proactively offer/determine any future PRS configurations tailored for certain cell/area/UEs/etc. This would be beneficial to avoid or mitigate any negotiation between the UEs and the network, hence improve latency for positioning. |
|  |  |  |

Further corresponding to the above cause, the UE can also be specific for which TRPs/ResourceSets/Resources that resulted in poor RSRP. Below UE reports the PFL, TRPs, ResourceSet and Resources in descending order of worse contributors for RSRP.

-- ASN1START

PoorRSRP-ContributorPFL-List-r17 ::= SEQUENCE (SIZE(1..4)) OF PoorRSRP-ContributorPFL-r17

PoorRSRP-ContributorPFL-r17 ::= SEQUENCE {

 positioningFrequencyLayerID-r17 INTEGER (1..4),

 trp-ContributorList-r17 SEQUENCE (SIZE (1..64)) OF TRP-Contributor-r17

}

TRP-Contributor-r17 ::= SEQUENCE {

 trpID-r17 INTEGER (0..255),

 resourceSetList-r17 SEQUENCE (SIZE (1..2)) OF ResourceSet-Contributor

}

ResourceSet-Contributor ::= SEQUENCE {

 resourceSetID-r17 INTEGER (0..7),

 resourceList-r17 SEQUENCE (SIZE(1..64)) OF INTEGER (1..64)

}

-- ASN1STOP

**Question 13: Do companies agree that providing worst offenders or best performer list to the NW can help NW to optimize PRS transmission? Further, please provide additional comments.**

|  |  |  |
| --- | --- | --- |
| Company | Worst/Best Performer List Yes/No | Comments |
| Qualcomm | No | This seems unrelated to on-demand DL-PRS. |
| ZTE | No  | The reason to request change of PRS configuration has been reflected in the UE initiated on-demand PRS request |
| OPPO | No  |  |
| Apple |  | In general we are open to discuss this, but the others are right – that should probably be a separate discussion. |
| CATT | No | Please see our response to Question 12. |
| Huawei, HiSIlicon | no |  |
| Convida |  | This could already be covered by existing measurement report(s), but it is helpful to associate the Q12 issues/errors to the specific TRP/gNB. |
| Xiaomi | No |  |
| Ericsson | Yes | To have the on-demand functionality work, it is essential that NW learns and adapts. If that loop is not there, the feature would be very weak.From NW perspective, it is not nice that UE always has to request its preferred configuration; NW should be able to provide without obtaining UE request. Hence, from a certain location if UE provides best and worst TRP list etc; NW will learn and adopt. |
| InterDigital | No | While we think there may be certain merits in providing to LMF such information, this may not be related or considered under the framework of on-demand PRS |
| Fraunhofer | Partially yes | Measurement on regular DL-PRS or any other DL-RS could be used to infer certain performance for on-demand DL-PRS (e.g. when they have similar spatial characteristics, or bandwidth, or transmit power).Measurement on best DL-PRS could be reported by the UE to help LMF make an on-demand trigger or request a suitable configuration.Combining measurements of several UEs for active PRS may help to optimize the PRS configuration (e.g. required power level).Content of additional measurements could be FFS. |
| vivo | No | The network configuration optimization based on UE report is not in the scope of this WI. Can be further discussed in other WIs, e.g. SON/MDT. |
| Intel | No |  |
| Lenovo, Motorola Mobility | Yes but | Similar response to Q12, the UE can provide information related to the quality of the positioning measurements using existing measurement report signalling and does not require a separate IE. The ranking of DL-PRS RSRP measurements can be potentially performed within the *ProvideLocationInformation* message (measurement report). |
| Nokia | No | This does not seem to be critical for a baseline on-demand PRS functionality. |
|  |  |  |

Additional Measurement Configuration to obtain feedback from UE for a sufficiently large set of PRS resource per TRP

As motivated in [7], UE feedback for on-demand PRS does not necessarily need UE support for new measurements; existing measurements can be reused instead. However, new configurations on existing measurements might be needed, which account for reporting a sufficiently large set of PRS resource per TRP measurements as part of UE feedback for on-demand PRS. UE feedback is crucial for on-demand PRS to understand whether the latest PRS resource allocation can meet the positioning requirements. As such, the UE feedback for this operation is feedback based on the PRS strength or quality received at the UE, such as PRS RSRP/RSRQ.

**Question 14: Do companies agree on the motivation for additional measurement configuration from UE such that UE provides feedback on the measurement quality of the latest PRS resource allocation?**

|  |  |  |
| --- | --- | --- |
| Company | UE feedback on latest PRS Resource allocation Yes/Mo | Comments |
| Qualcomm | No | Cannot see a reason why additional measurements are needed. It seems the questions 12-14 propose defining a kind of MDT/SON feature, which however, is unrelated to the on-demand DL-PRS feature. |
| ZTE | No | We are not clear why and what kind of additional measurement configurations are needed. |
| OPPO | No  |  |
| Apple |  | See above |
| CATT | No | This seems like within the scope of SON/MDT? Anyway, no potential benefit to support these additional measurements from the aspect of POS.  |
| Huawei, HiSilicon | no | Not clear about the reason |
| Convida | No | Existing measurements can be reused. It may be possible for the LMF to receive the on-demand DL-PRS request along with associated measurements that led to the request. |
| Xiaomi | No |  |
| InterDigital | No | See our response to Q13 |
| Fraunhofer | Yes | Evaluating measurements of several UEs allows to optimize the PRS configuration, but we also observe that reporting the whole set of DL-PRS in the assistance data would be a huge overhead. Then the question is, whether the high signaling overhead is justified for this gain.  |
| vivo | No | The network configuration optimization based on UE report is not in the scope of this WI. Can be further discussed in other WIs, e.g. SON/MDT. |
| Intel | No | The need for additional measurement reporting in this scenario is not sufficiently motivated in our view |
| Lenovo, Motorola Mobility | No | Motivations for new additional measurement configurations over the currently supported configurations is needed. |
| Nokia | No | Question and description of problem are unclear. |
|  |  |  |

##

# 5 Conclusion

TBD

# 6 Agreements

**RAN2-113bise**

Agreements:

UE-initiated on-demand PRS request is enabled by enhancing LPP RequestAssistanceData. FFS how much control the network has over the UE request.

The UE-initiated mechanism is enabled by the UE request triggering a request from the LMF, and the actual PRS changes are requested by the LMF irrespective of whether the procedure is UE- or LMF-initiated.

Put the stage 2 description for UE-initiated and LMF-initiated PRS request under the same framework.

**RAN2-114e**

Agreement:

The network can signal predefined PRS configurations to the UE and the UE can select one to request. FFS if the UE can request a configuration with different parameters and exactly which parameters are flexible.

Define a new LPP assistance data IE which can contain a set of possible on-demand DL-PRS configurations, where each on-demand DL-PRS configuration has an associated identifier.

The new LPP assistance data IE from Proposal 2 can be included in an LPP Provide Assistance Data message and/or a new posSIB.

The procedure(s) for on-demand DL-PRS should support at least the following functionality (up to RAN3 what is in NRPPa vs. OAM, etc.):

- Providing the requested on-demand DL-PRS configuration information from an LMF to the gNB (e.g., explicit parameter or identifier of a predefined DL-PRS configuration), and confirmation of the request by the gNB

- Provision of (possible/allowed) on-demand DL-PRS configurations that the gNB can support from a gNB to an LMF

- TRP capability transfer (e.g., whether the RAN node supports the reconfiguration of DL-PRS, etc.)

# 7 References

1. R2-2105217, "Discussion on on-demand PRS", Huawei.
2. R2-2105562, "Positioning enhancement to on-demand DL PRS", Xiaomi.
3. R2-2105734, "On-demand PRS", Fraunhofer.
4. R2-2105603, "On-Demand DL-PRS Support", Lenovo.
5. R2-2105704, "Considerations on positioning PRS On-demand", Sony.
6. R2-2106467***,*** Summary on agenda item 8.11.4 on on-demand PRS, Qualcomm
7. R2-2103998, On-demand PRS transmission considerations, Nokia
8. R2-2105969, "On demand PRS", Ericsson
9. R2-2103901, "On-Demand DL-PRS", Qualcomm
10. R2-2106355, Pre-configuration and initiation of on-demand PRS associated with QoS/radio conditions”, Nokia
11. R1-1906526, “Discussion on physical-layer procedures to support NR positioning measurements”, CMCC
12. R2-2104803, "Further discussion on on-demand PRS", CATT.
13. R2-2106379, “On-demand DL PRS transmission and reception”, Convida Wireless