**3GPP TSG RAN WG1 #100bis-E R1-20zzzzz**

**e-Meeting, April 20th – 30th, 2020**

**Source: Moderator (Intel Corporation)**

**Title: Summary of E-Mail Discussion #1 for AI 7.2.8.1 – DL Reference Signals for NR Positioning**

**Agenda item: 7.2.8.1**

**Document for:** **Discussion and Decision**

1. Introduction

This contribution is a part of Rel.16 maintenance work on NR Positioning. It provides summary of the RAN1 WG email discussion on UE DL PRS processing capability:

[100b-e-NR-Pos-01] Email discussion/approval on the following issues related to UE DL PRS processing capabilities by 4/24; if necessary, followed by endorsing the corresponding TPs by 4/29 – Alexey (Intel)

1. How to define duration for UE DL PRS processing capabilities
2. Reporting of UE DL PRS processing capabilities and T values
3. Dependence on BW and SCS
4. Simultaneous DL PRS processing across frequency layers
5. UE DL PRS processing capabilities for cases with and without measurement gap configured

The main goal of this discussion is to finalize details of the following UE DL PRS processing capability:

* Duration of DL PRS symbol in units of ms a UE can process every T ms assuming maximum DL PRS bandwidth in MHz, which is supported and reported by UE. Values for T = [0.125, 0.25, 0.5, 1, 40, 80, 160, 320, 640, 1280] ms
  + UE is not expected to support DL PRS bandwidth that exceeds the reported DL PRS bandwidth value
  + UE DL PRS processing capability is defined for a single positioning frequency layer
  + UE DL PRS processing capability is agnostic to DL PRS comb factor configuration
  + FFS if UE DL PRS processing capability is agnostic to the configured SCS settings of DL PRS
  + FFS if reported values of T are the same across bands within a FR or across FRs
  + FFS cases w/ and w/o configuration of measurement gap

1. Collection of Company Views
   1. Definition of Duration for UE DL PRS Processing Capabilities

### Round #1 (Initial Collection of Views)

In this section, companies provide views how to define duration for DL PRS processing capabilities. Companies are invited to provide views on the following questions:

1. What is the definition for duration of DL PRS symbol in units of ms a UE can process every T ms assuming maximum DL PRS bandwidth in MHz?
   1. Companies are invited to provide full definition according to their interpretation, including aspects whether symbols not carrying DL PRS are considered or not, whether and how symbols carrying DL PRS from multiple TRPs are taken into account or not, etc. and which changes need to be made if any?
2. Whether and how two DL PRS resource sets configured per TRP with the same or different periodicities per positioning frequency layer are handled in the definition of duration?
3. Other comments

Table 1: On definition of duration for UE DL PRS processing capabilities

|  |  |
| --- | --- |
| Company | Comments |
| Qualcomm | We are generally supportive of defining the N1 = PRS symbols in msec, using “potential” PRS symbols by considering not only the configured PRS symbols but also their uncertainty window.  To dive into the details directly, with regards to detailed PRS symbol duration definition, having as a starting point the Proposal 4 from HW/HiSi [R1-2001558], we have the following clarifications questions:   1. With regards to this bullet:   *is smallest interval in ms within slot that covers the union of the potential PRS symbols from all TRPs, each of which is determined by nr-DL-PRS-ExpectedRTSD, nr-DL-PRS-ExpectedRSTD-Uncertainty, and the PRS symbol occupancy within slot .*  From our side, a UE is buffering “whole” OFDM symbols, so the buffering should be symbol aligned, so I would say a better starting point should be:  is smallest interval in ~~ms~~ **an integer number of OFDM symbols for the given numerology μ** within slot that covers the union of the potential PRS symbols from all TRPs, each of which is determined by *nr-DL-PRS-ExpectedRTSD*, *nr-DL-PRS-ExpectedRSTD-Uncertainty*, and the PRS symbol occupancy within slot .   1. With regards to this aspect:   *S is the smallest set of consecutive slots within the PRS periodicity in the positioning frequency layer that contains all PRS across TRPs*  Why doesn’t it say “potential” PRS across TRPs? Specifically, note that the search window of a PRS may span across consecutive slots, even if the configuration is limited within single slot. For example, for a PRS configured in the last symbol of a slot, in FR1 with 60 Khz, the search window may spill over to the first 2 symbols of the next slot (up to 32 usec).  So, I would assume that in this TP, the following change would at least be needed:  *S is the smallest set of consecutive slots within the PRS periodicity in the positioning frequency layer that contains all* ***the potential*** *PRS across TRPs,* ***each of which is determined by nr-DL-PRS-ExpectedRTSD, nr-DL-PRS-ExpectedRSTD-Uncertainty, and the PRS symbol occupancy.***   1. We observe that a single [start, end] interval is considered within each slot.   Then, in the scenario shown below, is it indeed true that the PRS duration would include the 2nd slot also in the calculation, exactly because the definition assumes that within each slot there can be only one interval of [start,End]?     1. We don’t see the need of defining a single periodicity. When, the UE reports a (N1,N2,T), the requirements of the N1 PRS symbols in msec would be defined within any T window, independent of whether there are multiple periodicities or not, and independent of whether the slots are consecutive or not. So, assuming we use the same TP as a starting point, **these** constraints do not seem necessary to us, and just adding **this** seem enough.   *UE is configured by higher layers to receive PRS symbols ~~with the periodicity~~ , the PRS symbols duration* ***within any T msec window****, shall be calculated by*  *-*  *-*  *where*  *- is the smallest set of* ***~~consecutive~~*** *slots* ***~~within the PRS periodicity~~*** *in the positioning frequency layer that…* |
| Huawei/HiSilicon | We think the clarification is needed.  For PRS duration   * First, PRS slots may not be continuous. * Second, PRS duration in a slot may be different between slots. * Third, PRS duration in a slot may be partially overlapping and the offset may exceed CP length, which is why we need expected RSTD and expected RSTD uncertainty.   When it comes to different PRS periodicities within a positioning frequency layer, it will be hard for both UE and LMF to decide whether and how UE supports the configuration based on the capability, which is why we suggest to keep it the same for Rel-16.  In response to QC’s question above:   * + 1. The operation of taking symbols is taken into account by . We are fine either way.     2. Regarding the spill-over, we assume that it is possible. In case of that, we think that it is up to UE to select the slot boundary to reduce the occurrence of double-sided spill-over for a slot (middle slot in the figure). Note that the maximum occupancy of a PRS resource is 12 symbols. In general, we are also OK with the change proposed by QC, so that when determining the slot, the search window should also be considered.     3. Our original intention is to buffer the continuous symbols in a slot. The spill-over issue is indeed a good example. Our suggestion is up to UE to select the slot boundary to overcome the issue, i.e. the slot boundary does not have to be that of the reference TRP, or of any serving cell. UE should try its best to set the slot boundary to reduce the number of impacted slots.   4. So our proposal here is to calculate the duration and periodicity based on PRS configuration. You can see that there is no N or T, and we intentionally use K and P, instead. This (K, P) will be used to compare with UE capability (N,T) for the LMF to decide whether and how UE supports the configuration. For example, LMF may need to decide to remove some PRS configuration or increase the PRS periodicity (in AD, not real periodicity) so that both UE and LMF knows that K<=N, and P>=T with the configuration. Another issue that needs further discussion is whether UE can be provided with more PRS (longer duration K and/or shorter periodicity P) than its reported capability (N, T), and if so what kind of UE behaviour is expected, e.g. UE do RR measurements every 2P if K=2N, and P=T. Having the restriction of single periodicity on a positioning frequency layer simplifies the entire discussion, and we think that is the typical deployment, although the configuration have its flexibility to do otherwise. |
| Qualcomm2 | **Regarding 1:**  Yes we believe the and need to be considered aligned to symbol boundaries by definition.  **Regarding 2**: OK, yes we think this is needed otherwise the UE may need to buffer more than what the network assumes.  **Regarding 3** I just wanted to point out that this spill-over is happening, and when the buffering is happening in a single interval [Tstart, Tend] within a slot, there can be cases that the whole slot is assumed to buffered even though there is no PRS configured within that slot.    **Regarding 4**, I didn’t want to explicitly add N and T, I just wanted to point out that a frequency layer may have multiple periodicities and we don’t see the need for single periodicity. So, to use the same K and P notation, it can just be:  *UE is configured by higher layers to receive PRS symbols ~~with the periodicity~~ , the PRS symbols duration* ***within any P msec window****, shall be calculated by*  *-*  *-*  *where*  *- is the smallest set of* ***~~consecutive~~*** *slots* ***within the P msec window******~~within the PRS periodicity~~*** *in the positioning frequency layer that…*  BTW, related also to a later comment: It should be clear that, if the configured PRS resources does not satisfy the UE capabilities, the PRS processing time discussed in RAN4 would increase. It does not mean that the UE would not accept the assistance data. |
| CATT | 1. We are fine to either use  *is smallest interval in ms within slot ,…*  Or  is smallest interval in ~~ms~~ **an integer number of OFDM symbols for the given numerology μ** within slot  The latter seems making the calculation of the simpler, i.e., -.  2. About the spill-over issue, I am wondering if we really need to take the scenario into the account of the calculation given that it may potential has some impact on the calculation of when DL PRS are not transmitted in sequential slots, which when there are large and expected RSTD is very large?  3. About the scenarios that UE is configured with more DL PRS resource than UE can handle with its reported capability, should we assume the UE can simply process the DL PRS resource based on its capability up to UE’s implementation, assuming the performance requirements also be defined based on its capability but not based on the configured DL PRS resource in this case. |
| OPPO | The case that two PRS resource set configured with different periodicities seems not necessary be included in the definition. All the PRS from all the TRPs shall meet the requirement of DL PRS symbol length within each T ms time duration. |
| vivo | Seems to us this whole definition of UE DL PRS symbol duration K is to align the assumption/understanding between UE and LMF regarding the reported UE capability of (N, T). We’re okay with this intention in general.  However, we’re not sure this proposed TP should go to clause 5.1.6.5 of TS 38.214. The wording “If UE is configured by higher layers to receive PRS symbols with the periodicity , the PRS symbols duration shall be calculated by …” seems indicating for any PRS configuration and reception, UE shall calculate K as part of PRS reception procedure. I don’t see why this should be the case. This K calculation should just be a common assumption for UE PRS processing capability report, not for PRS reception at all. |
| Huawei/HiSilicon2 | We provided our answer to the questions from other companies:  Issue 1: In response to QC/CATT, I use the following example to show. Given a single duration, based on different symbol timing hypothesis, the resultant number of symbols will be different. For hypo-1, 4 symbols will be counted, and for hypo-2, 3 symbols will be counted. The problem originate from which hypothesis LMF assume that UE would use, e.g. a smart UE that minimizes the number of symbols affected, or the worst case scenario, or the symbol timing should be based the reference TRP. Using ms representation for and give more freedom to further consider how to quantize the affected symbols.  To our understanding, an example of quantizing the affect symbols is shown to be using , where the symbol boundary could be based on the reference TRP, the TRP with the latest arrival, or the serving cell.    Issue 3: We assume that would be resolved by UE, by selecting the slot/symbol boundary based on the TRP with the latest potential arrival. We suggest that the duration calculation should be easily done by the LMF so that LMF can effectively select the assistance data to match the UE capability. On the other hand, from UE perspective, we prefer not to buffer discontinuous burst within a slot, which we think would not be typical and may increase the buffering complexity.  Regarding multiple periodicities, we use the following example. For example, if UE support T = 160ms, and PRS periodicity are 160ms, 320ms, and 320ms for set 1, set 2, and set 3, respectively. It will be observed that if we select the window to be T1=T, followed by T2=T, and within T1, the duration of PRS symbols is N, and within T2, the duration of PRS symbol is less than N, it should be supported by some UE based on capability definition, but the UE buffering positioning is different in T1 and T2. However, if we go with sliding window, e.g. we select T’, the duration will exceed N, as part of PRS set 3 will be in T’. Is it correct understanding that it such a configuration exceeds UE capability for the sliding window?    Having single periodicity would facilitate the following:   * The same buffer positioning within the periodicity, which means that duration calculated in one periodic occasion is applicable to other periodic occasions. * A single periodicity will include all PRS resources, based on which RAN4 can easily define the latency requirements.   Having multiple periodicity will further complicate the discussion if one periodicity is from 2^n slot series, and another periodicity is from 5\*2^n slot series.  If there is indeed need to support multiple periodicities on a positioning frequency layer, we suggest to limit the periodicities to have the following structure so that either   * That there exists a PRS resource set, whose periodicity can divide the periodicities of all the remaining PRS resource sets on a positioning frequency layer, or * That there exists a PRS resource set, whose periodicity can be divided by the periodicities of all the remaining PRS resources are the factor of the periodicity   We should not have one with 4 slots periodicity, while another has 10 slot periodicity.  Regarding more PRS than UE can process, can we have an intermediate conclusion such as following   * The discussion of PRS processing capability does not imply that the PRS provision in the assistance data should be within UE processing capability. * FFS UE behaviour/LMF expectation in case UE is provided with more PRS than it supports.   In response to vivo, we think that clarifying how to calculate the duration will help   * UE to decide what to report in the capability (N, T) based on hardware limitation * LMF to select assistance data to match the UE reported capability * LMF to provide the measurement window to comply with UE reported capability (not agreed yet) * LMF and UE to determine the latency requirement in case that the assistance data exceeds the UE capability   We update the TP as follows  If UE is configured by higher layers to receive PRS symbols [with the periodicity ], the PRS symbols duration shall be calculated by  *-*  *-*  where  *-*  is the smallest set of slots within [the PRS periodicity] in the positioning frequency layer that contains all the potential PRS across TRPs, each of which is determined by *nr-DL-PRS-ExpectedRTSD*, *nr-DL-PRS-ExpectedRSTD-Uncertainty*, and the PRS symbol occupancy within slot  *-*  is the numerology of the PRS resources in the positioning frequency layer  *-*  is the number of symbols in a slot  *-*  is smallest interval in ms within slot that covers the union of the potential PRS symbols from all TRPs, each of which is determined by *nr-DL-PRS-ExpectedRTSD*, *nr-DL-PRS-ExpectedRSTD-Uncertainty*, and the PRS symbol occupancy within slot . |
| Intel | It looks to us that discussion from UE DL PRS processing capability reporting is shifted to the definition of the procedure that can be used by LMF, which is not our preference. We would like to see much more simplified procedure:   1. We prefer not to couple UE DL PRS processing capability report with the actual configuration of the values for nr-DL-PRS-ExpectedRTSD, nr-DL-PRS-ExpectedRSTD-Uncertainty. We assume that UE capabilities are reported w/o assumption on actual configurations of DL PRS configuration settings (i.e. can be done before assistance data are delivered to UE) 2. RAN1 was supposed just to clarify assumption on what is meant by duration in ms in the previous agreement rather than define new procedures. 3. We believe it useful to clarify it only for the purpose of UE capability report. The following clarifications are needed    1. How to calculate duration of PRS occupation within a slot and across slots with time window T |
| Huawei/HiSilicon3 | In response to Intel, we would like to clarify that this is not related to LMF calculating.  Step.1 When UE do the reporting, UE simply report the value based on its hardware.  Step.2 When LMF receives the UE capability, LMF may or may not calculate the duration, and may or may not decide to trim the assistance data.  Step.3 When UE receives the assistance data, UE needs to check if the PRS configuration is within its processing capability.  Here we tried to clarify the operation in Step.2 and Step.3, which in turn helps UE do the reporting in Step.1, since the UE hardware should support any PRS configuration whose duration and periodic falls below its reported capability. |

### Round #2 (Comments on Initial Proposal)

Based on discussion in the previous sub-section, the following proposal is suggested for further discussion.

**Proposal 1**

* **For the purpose of DL PRS processing capability and report, the duration of DL PRS symbols (*N*) in ms within any *T*W msec window, is calculated by**
  + **where,**
    - **is the set of slots within the *T* msec window in the positioning frequency layer that contains DL PRS resources**
    - **is smallest interval in ms within slot that covers the union of the potential PRS symbols and determines the PRS symbol occupancy within slot . Further discuss and select one of the following alternatives:**
      * **Alt 1: Interval does not consider nr-DL-PRS-ExpectedRSTD, nr-DL-PRS-ExpectedRSTD-Uncertainty**
      * **Alt 2: Interval considers some predefined margin to accommodate potential difference that may happen due to practical settings of nr-DL-PRS-ExpectedRSTD, nr-DL-PRS-ExpectedRSTD-Uncertainty (FFS value +/32 us can be considered)**
      * **Alt 3: Interval considers the actual nr-DL-PRS-ExpectedRSTD, nr-DL-PRS-ExpectedRSTD-Uncertainty provided for each pair of DL PRS Resource Sets (target and reference)**

Companies are invited to comment on proposal 1 above.

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| **Company** | **Comments** |
| Huawei/HiSilicon | We suggest to use K instead of N, and P instead of T, which is based on actual PRS configuration. Spec will simply say that if K<=N and P>=T, UE is capable of processing the PRS, so as to grant the meaning of (N, T). Similar practice has been adopted in Rel-15 CSI processing unit (CPU).  Another reason is that UE will not know the configuration of PRS in the capability reporting, it does not make any sense to calculate N in this way.  Our logic is that:   * We specify how the duration K is calculated via actual PRS configuration, and how the periodicity P is calculated via actual PRS configuration. * If duration K <= N, and periodic P >= T, it means that UE is capable to receive all PRS. * Otherwise, it means that UE is capable to receive all PRS, and we may need to define a rule how UE selects the PRS to receive or leave it up to UE implementation.   Please consider it. |
| Qualcomm | To some earlier points raised by HW: Our assumption is the UE has a single FFT engine and just process OFDM symbols using serving cell timing. We don’t assume advanced FFT placement just for the purpose of receiving PRS symbols. Having a conservative assumption should be preferred, and everything else could be left up to UE implementation. This is actually also the assumption on having “single interval” inside each slot: A UE can do something more advanced which can be left up to UE implementation.  With regards to the exact proposal shown above:   * “***S***” should be the set of slots that contains **potential** PRS resources. We showed a specific example, the PRS is going into the next slot. If this is not addressed, there would be a confusion and a UE would be buffering more, than what is accounted for. * The interval within a slot should be aligned with OFDM symbol boundaries from the serving cell, any additional optimization can be left up to UE implementation. We should not assume advanced/smart PRS buffering, nor a second FFT engine at the UE. Therefore, the baseline assumption would be that the UE is buffering the OFDM symbols on the serving cell timing.   **is smallest interval in ms corresponding to an integer number of OFDM symbols of the serving cell that covers the union of the potential PRS symbols and determines the PRS symbol occupancy within slot**  For us, the above changes are essential.  Under the above changes we prefer Alt. 3. Alt. 1 would not work. Alt. 2 again we don’t see how it will work. The worst-case expectedRSTD can be +- 500 usec.  We are OK to change to K and P, than using the (N, T) which may be confused with the reported UE capabilities. |
| Nokia/NSB | We are okay with Alt. 3. |
| CATT | Our preference is also Alt.3. Additional comments:   1. We think should be calculated as follows:   For example, if the potential DL PRS occupy part of symbol#0 and symbol#1. We should have **; and =2.**   1. The potential slot *s* includes the slot that are configured with DL PRS resource, but may have potential DL PRS symbols due to *nr-DL-PRS-ExpectedRSTD* and , *nr-DL-PRS-ExpectedRSTD-Uncertainty* 2. We also prefer to use *K* and *P.* |
| vivo | We don’t know how this Alt. 3 can work.  So a UE cannot report DL PRS processing capability N if there’s no PRS configuration as Alt.3 says N calculation “considers the actual nr-DL-PRS-ExpectedRSTD, nr-DL-PRS-ExpectedRSTD-Uncertainty provided for each pair of DL PRS Resource Sets (target and reference)”.  Furthermore, is the intention of Alt. 3 to update UE reporting of N based on each PRS configuration? |
| Huawei/HiSilicon2 | We agree with QC in general. Perhaps we can change “the serving cell” to “a serving cell”, since UE may have different DL timing in case of CA, and PRS may be transmitted on a band without any CC, although UE supports that band.  **is smallest interval in ms corresponding to an integer number of OFDM symbols of ~~the~~ a serving cell that covers the union of the potential PRS symbols and determines the PRS symbol occupancy within slot**  For CATT’s proposal, I think it is reasonable only if and were counted as the symbol number index, but our understanding is that it should be counted in ms, which means that the starting time of the first symbol, and the ending time of the last symbol in ms. The duration (N or K) is also written in ms.  To vivo’s comments: If UE understands how the duration is calculated when UE receives ignaledtion, UE will make a better judgement when it comes to capability reporting, also based on its software/hardware budge. |
| Qualcomm2 | To vivo: No the UE would not report capability for different PRS configs obviously. The UE makes a decision on how to report assuming some reasonable configuration, or it could report assuming worst-case configuration, all that, is left up to UE’s implementation and responsibility always. Then, when the LMF makes a decision on the PRS configs, by using the reported UE’s capability, it also determines how long would be the PRS measurement latency be, the UE is expected to meet this latency and the Ran4 positioning requirements.  We are OK the “a serving cell”. With regards to and **,** they are counted as ms but correspond to the start of an OFDM symbol and the end of another OFDM symbol. |
| mtk | In our view for UE implementation,   * the capability of N stands for memory buffer size * the capability of T stands for hardware/DSP processing MIPS   If N is calculated according to the number of PRS symbols, plus RSTD-uncertainty, for example, comb-4 with 4 symbols in 6 consecutive slots, which results in N = 24/14 ms + RSTD-uncertainty, this may imply that the UE should be able to determine the timing at the first slot, so that for the following slots, the UE can accurately buffer at the right timing.  We think that the feasible buffering mechanism is to buffer all the symbols for later processing, no matter it is comb-4 with 4 symbols, or it is comb-12 with 12 symbols. So we suggest that N can be considered as the **total slot number time** + RSTD\_uncertainty for buffering, not just PRS symbol number time+ RSTD\_uncertainty.  T and number of resources per slot may determine the processing latency, which is also related to the reporting delay, due to the DSP MIPs consideration. For example, a UE can process with T=160ms and 4 TRPs ( four comb-4 signals). Then it is equivalent to T= 480ms and 12 TRPs (twelve comb-12 signals) |
| Samsung | In general, N1 should only count for the symbols that contain PRS. Furthermore, the time difference between different TRPs could be included in N1 when PRS symbols are from multiple TRPs. |

* 1. Reporting of UE DL PRS Processing Capabilities

### Round #1 (Initial Collection of Views)

In this section companies provide views how to report UE DL PRS processing capabilities.

Companies are invited to provide views at least on the following aspects:

1. Format of reporting UE DL PRS Processing capability (e.g. duration + processing time, etc.)
2. Whether reported values of T are the same across bands within a FR or across FRs
3. FR1/FR2 differentiation aspects
4. Values for reported parameters
5. Other comments

Table 2: On reporting of UE DL PRS processing capabilities

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| --- | --- |
| Company | Comments |
| Qualcomm | We have a detailed proposal with values, and we encourage companies to read the reasoning in R1-2002557, that we are not repeating here for the sake of brevity:   * *Duration of* ***DL PRS symbol in units of ms (N1)*** *and* ***number of PRS resources (N2)*** *across all TRPs a UE can process every T ms assuming a maximum DL PRS bandwidth in MHz (Bmax) for a reported SCS.*    + *Values for T = {0.125, 0.25, 0.5, 1, 2, 4, 8, 16, 20, 30, 40, 80, 160, 320, 640, 1280} ms*   + *Values for N1 = {0.125, 0.25, 0.5, 1, 2, 4, 8, 12, 16, 20, 25, 30, 35, 40, 45, 50} ms*   + *Values for N2 = {1, 2, 4, 6, 8, 12, 16, 24, 32, 48, 64, 96, 128, 256, 512, 1024} resources*   + *Values for Bmax = {10, 20, 40, 50, 80, 100, 200, 400} MHz*   + *For each SCS, the UE reports*      - *a single Bmax*     - *One or both of the following two:*       * *one (N1,N2,T) for T = “slot duration” with*       * *one (N1,N2,T) for T > “slot duration” with*   + *This capability is reported per band* * *The capability is reported separately for MG configured or not. When a UE does not report this UE DL PRS processing capability, the UE does not support DL PRS processing without measurement gaps*   Beyond the detailed proposal, we would like to emphasize the fact that according to agreements both N1 and N2 must be defined:   |  | | --- | | **Agreement**  Duration of DL PRS symbols in units of ms a UE can process every T ms assuming 272 PRB allocation is a UE capability |  |  | | --- | | Agreement:  A limit on the maximum number of DL PRS resources configured to the UE for all TRPs within a measurement window is defined.   * This limit can be ignaled as a UE capability. |   We consider both agreements to be clear and need to be captured clearly in the UE features (which hasn’t happened until now). A technical comment that was received was whether N2=X7 or it can be smaller, and this can be FFS and for further discussion. So at a minimum the discussion should be about (N1,N2,T), with FFS: N2=X7. |
| Huawei/HiSilicon | 1) Multiple (N, T) reporting should be allowed.  2) If multiple (N, T) are reported, we may need to consider if the multiple pairs should have the same set of T values across bands within a FR or across FR.  Currently we think the different T values may still work.  3) Since it is reported per band, probably we do not need FR1/FR2 differentiation.  4) The reported value can be discussed in the UE feature session.  Regarding QC’s comments, what is unclear from the agreement is related to “a measurement window”. In our understanding the measurement window is something independent from (N, T), rather UE reports the number of resources, and network configures a measurement window that complies with (N, T) and also contains no more than the number of resources.  Since multiple (N, T) values may supported, and different (N, T) values may be associated with different N2, which justifies the introduction of (N,T)-wise N2 on one hand, we have concern for the LMF to handle so many Ues with different capabilities on the other hand. Therefore introduction of N2 should allow network to provide more PRS than UE reported N2 in “the measurement window”, and this will have impact on TTFF latency, which will be evaluated by RAN4. |
| Qualcomm2 | From our side, it was not unclear what “measurement window” refers to, and I clearly remember clarifying it online when the 2nd agreement was made. In one agreement we talked about “T msec”, and in the other agreement we talked about “measurement window” which correspond to capabilities reported by the UE.  Yes, a network can always provide more PRS than (N1,N2,T) and then it would just increase the latency discussed/evaluated/decided in RAN4 (discussion already started). I assume this is a common understanding. |
| Nokia/NSB | 1) Our view is that (N, T) should be reported where N is the duration of DL PRS symbols in units of ms. An additional value lets call it X can then be signaled which relates to the 2nd agreement that QC quotes. If needed as X may be equal to X7 from another agreement. The tying together of these reporting quantites is assumed by QC but from our view these are separate agreements that were not agreed to be tied together for reporting.  2/3) We see value in having (N, T) reported per FR but within one FR the UE should just report one set at most.  4) We think that the values T which are being proposed are a bit confusing. What is the value of knowing the UE can process some amount of DL PRS within 1/8 of a ms? Performance targets should be considered, and we think that value ranges for T such as [1,40,320,1280] are much more reasonable. For values of N we are a bit more flexible as this should cover the variety of SCS options, something like [.25,1,4,8,16,40] ms could be a good starting point. |
| Qualcomm3 | The agreement was saying that this X is the number of PRS resources within a measurement window. In the reply from Nokia, what is the measurement window? Is the proposal the UE to report a second T2 for this X? I don’t think so, and that is why we proposed to tie them with the N, to avoid the additional report of T. If the proposal is to have: (N, T1) and (X,T2) we are also fine clearly.  The T = 1/8 was for the case of SCS = 120 Khz, when the UE reports the max number of PRS resources per slot:   * + - *One or both of the following two:*       * *one (N1,N2,T) for T = “slot duration” with*       * *one (N1,N2,T) for T > “slot duration” with*   Yes, performance targets are considered to say the maximum number of PRS resources the UE can process within a slot. |
| CATT | For the Values for T, we like to understand the intention and usage when the T is smaller than the smallest DL PRS transmission period. From the network point of view, we are more interested in UE’s DL Processing capability for each DL PRS transmission period in order to configure the DL PRS resources within the DL PRS transmission period. With the values of T being the values of DL PRS cycles, the LMF will know whether the UE can process the DLPRS with the configured DL PRS period.  We are fine to support multiple values for the (N,T) pair. We may also define one or more N2 values for each (N, T) pair. |
| OPPO | 1. UE reports {time duration of PRS symbols, T ms}. 2. The UE shall report those values per band. 3. The UE shall report those values for with MG configured or without MG configured. |
| Vivo | 1) Multiple (N, T) pairs should be allowed, where N is the duration of DL PRS symbol in units of ms.  2) If multiple (N, T) are reported, our preference is that multiple pairs should have the same set of T values across bands within a FR.  3) No need FR1/FR2 differentiation assuming this UE capability is reported per band  4) Our preference of the reported values for T is to be a subset of PRS period.  Our understanding regarding the agreement quoted by Qualcomm about “A limit on the maximum number of DL PRS resources configured to the UE for all TRPs within a measurement window is defined.” Is actually the same thing as X7. It’s clear to us that the limit which can be signalled as a UE capability is on the number of DL PRS resource. I don’t see how it can be interpreted that the limit is about the measurement window and hence report of multiple of T2. |
| Qualcomm4 | To Vivo:   * Assume the UE reports X7 = 1000 PRS resources. Can these all be configured within the same slot and expect the UE would process them?   + Please consider a real-time PRS processing scenario. * Assume the UE reports X7=100 PRS resources without any relation to any timing aspec, but gets assistance data with 1000 PRS resources. Is the UE expected to drop the assistance data? I assume no right? So RAN4 need to define the PRS latency, that is how long a UE needs to process the configured PRS resources. How would we define a PRS latency if we don’t know how many PRS reosurces the UE is processing in a unit of time?   Maybe it is better if complete alternative proposals are shown that can address the technical concerns.   * Is the alternative that the UE reports (N,T) and then X7 is the number of PRS resources the UE process within T? * Then, how would a real-time UE processing be associated with such a type of proposal?   + Would there be a minimum number of PRS resources the UE can process within a slot that is specified and not reported as UE capability?   We have technical concerns here. There needs to be a report of how many PRS resources a UE can process within a small period time (like a slot). On the other hand, for PRS buffering (N), a typical value associated with it would be a large T (e.g. 20 msec worth of PRS every 160 msec). |
| vivo2 | In response to Qualcomm:  Thanks for following up. At least on the PRS buffering part of N, we seem to have the same understanding that T should be in a time interval similar to PRS periods (not < 1 ms).  We never said UE reports X7 without any relation to any timing aspect. Our concern is that this T2 (corresponding to a measurement window) should not be the same value as T for N. On your argument of so called real-time PRS processing, we’re open to consider reporting (N2, T2). |
| Huawei/HiSilicon2 | Thanks for the clarification from QC. Based on the explanation, would that be easier to introduce number of PRS resources that UE can process in a slot? We are fine if such a parameter as X8 is introduced.  Regarding measurement window, our understanding is that a dedicated measurement window configured by LMF to instruct UE to only measure PRS within the window, similar to SMTC. UE report the maximum number of resources, and LMF sets the window to fit the number of PRS resources within the window does not exceed UE reported capability. |

### Round #2 (Comments on Initial Proposal)

Based on discussion in the previous sub-section, it seems there is no consensus to report combination of the {Duration of Symbols in ms, Number of resources across resource sets, Processing time}. Therefore, the following proposal is suggested for further discussion.

**Proposal #2**

* **For UE DL PRS processing capability,**
* **UE at least reports multiple combinations of (N, T) values, where N is a duration of DL PRS symbols in ms (based on definition in section 2.1) processed every T ms for a given maximum bandwidth (B) in MHz supported by UE**
  + **Alt 1. Number of resources (NR) across all DL PRS resource sets in frequency layer is added to the combination of (N, T)**
  + **Alt 2. Number of resources (NR) across all DL PRS resource sets in frequency layer is not coupled with the combination of (N, T) and new combination of (NR, TR) is additionally reported**
  + **Alt 3. Additionaly report new parameter – number of DL PRS resources that UE can process in a slot**
  + **Note: companies are encouraged to resolve FFS within meeting week**
* **The following sets of values for N, T and B are supported**
* **Values for N = {0.125, 0.25, 0.5, 1, 2, 4, 8, 12, 16, 20, 25, 30, 35, 40, 45, 50} ms**
* **Values for T = {1, 2, 4, 8, 16, 20, 30, 40, 80, 160, 320, 640, 1280} ms**
* **Values for maximum BW reported by UE = {10, 20, 40, 50, 80, 100, 200, 400} MHz**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei/HiSilicon | Where is FFS? Do you mean down-selection between Alt. 1 – Alt. 3?  We support Alt. 3.  Regarding values for BW, since this is reported per band, do we need different candidate values for FR1 band and FR2 band? |
| Qualcomm | We can accept Alt. 3 if the UE can report a different value of PRS resources it can process **within a slot for different SCS**. In FR1 band, that means 3 values, in FR2 band, that would mean 2 values, and there is no need to report a second T.  Example:   * If the UE says that it can process 1 PRS resource of 200 MHz in FR1, this means that the SCS is 60 Khz so, this UE can process **272 PRBs every 0.25 msec**   + The same UE, in 15 KHz of 50 MHz, which still corresponds **to 272 PRBs, will have 4 times more time to finish the processing.**   + Why not allow the UE to report that it can more PRS resource processing when a slot duration is longer?   The UE would be underreporting the #PRS resources per slot, because in the worst case, a slot can be 0.25 msec in FR1, and 0.125 in FR2. **There would be an approximate factor of underreporting of ~4 in FR1 and ~2 in FR2.**  Another reason that this scaling is needed due to the search window. Specifically, and just to show a FR2 example, the FR2 expectedRSTD-uncertainty is limited to +/- 8 usec, i.e. a total search window spanning 2\*8sec = 16 usec. So, for 60 Khz, this would correspond to +- 1 symbol, and for 120 Khz, it would correspond to +-2 symbols that the UE would need to be computationally budgeted to be able to process. Therefore, in the worst case expectedRSTDUncertainty search window, a UE may need to process significantly more OFDM symbols in 120 KHz, than in 60 Khz for the same PRS resource configuration. So, a UE would have to be able to say how much processing it can do assuming 120 Khz and 60 KHz separately. |
| Nokia/NSB | We would like to include 5 MHz as an option for the reported bandwidth. We could consider accepting Alt. 3 if the range of values is shrunk as suggested in our previous comments. Do we really need the UE to be able to report for T =1,2,4? We also suggest that we get more specific about the UE being able to report multiple values of (N,T). Is it the right understanding that the UE would report at most 1 per band? We would prefer to see this as at most 1 per FR. |
| Qualcomm2 | We understand the constraint from Nokia that want fewer differentiations of the Ues, and we are trying to accommodate the situation. However, we also request companies to understand that we have significant technical concerns if the #PRS resources per slot (Alt.3) is not reported per SCS of the band.  In a spirit of middle ground here:   * We would be OK to have single (N,T) per band, * We would be OK start with larger values of (N,T) , e.g. start form (N=8, T=16) * We are OK to add 5 MHz in the B   **Assuming** that the X8 (#PRS resources per slot) is reported per SCS of the band, and the values start from 1 (e.g., X8 = {1,2,4,8,16,32,64}). Minimum values per band per SCS that the UE can report can be considered in the UE feature discussion (e.g., X = 1 in 15 Khz slot may not be needed) |
| CATT | As we comment before, we don’t see the usage of T when it is smaller than then smaller than the smallest DL PRS transmission period, which is 4ms.  For Alt.3, we like to understand what it means by “number of DL PRS resources that UE can process in a slot”. One DL PRS resource may contain difference number of OFDM symbols, different comb-N. So, we assume the UE may be able to process different number of DL PRS resources with different configurations. Let us assume the UE can process 100 DL PRS resources in a slot, does it mean the UE can process 100 DL PRS resources regardless what the configuration of the DL PRS resources? |
| Qualcomm3 | We are Ok to start with the smallest PRS transmission period supported in NR (we actually proposed T = 16 msec above).  With regards to CATT question. Clearly a UE has to do its book-keeping and analysis and determine across the worst case (comb and number of symbols) and report that value. I don’t think companies would be open in making comb or number of symbol specific, if already adding the SCS as a factor has been so difficult.  So our current compromise proposal is to keep (N,T) SCS-agnostic, but at least allow the #PRS resources per slot to be reported for each SCS for the reasons described in the reply in Qualcomm2. |
| Vivo | With regards to Qualcomm’s proposal to have the #PRS resources per slot to be reported for each SCS, we’re wondering whether this can be done with Alt.2 with multiple pairs of (NR, TR) where values of TR can be corresponding to a slot for different SCS.  Then both (N, T) and (NR, TR) can be SCS-agnostic. |
| Qualcomm4 | To vivo: yes (NR, TR) could still work, where TR is in units of msec, and the available options would be {0.125,0.25,0.5,1}, but it opens up the discussion with more cases also. So, for a FR1 band, to report multiple (NR, TR): the UE would report: (NR1, 0.25), (NR2,0.5), (NR3,1), but would it ever make sense the (NR1,0.25) in 15 KHz? We would have to say that it doesn’t make sense, so eventually we go back to the SCS-specific:   * (NR1,0.25) applies for 60 Khz, (NR2, 0.5) applies to {60?,30}, (NR3, 1) applies to {60?, 30?, 15} Khz.   I see companies asking more questions, e.g., that is why we considered simpler to just do NR per slot for each SCS of the band.  Overall, we would also be OK if we go with Alt. 2 assuming the UE can report 3 values in an FR1 band and 2 in FR2 band. |
| Huawei/HiSilicon2 | We support including 5MHz, as it was evaluated in the SI.  We suggest not to overcomplicate this regarding Alt.2, where TR is simply slot duration for each SCS. In that sense, we support Alt. 3 with compromising with adding per SCS reporting, but we do not think it needs to be reported per band, since it is already reported per SCS.  To CATT: My understanding of adding number of resources per slot is that the effective REs after de-staggering for the UE to process is generally 12 \* NRB \* Nres per slot, also 12 \* (NRB \* Nslot) \* Nres per 1ms; it does not scale w.r.t. comb size and number of symbols at least for (2,2), (4,4), (6,6), and (12,12). It may add a marginal buffering effort when it comes to (4,2), (6,2), (12,2), (12,4), (12,6).  Note that (NRB \* Nslot) does not scale with SCS, given a bandwidth. For example, given 50MHz, we have approximately 270 RB \* 1 for 15kHz, and 133 RB \* 2 for 30kHz, and 65 RB \* 4 for 60kHz.  So my understanding is that by reporting number of resources in slot, given a maximum bandwidth, the total number of REs after destaggering does not scale with SCS. |
| Samsung | We support the PRS processing capability in the format of multiple pairs of (N1, T) assuming a max PRS bandwidth, which is reported for each SCS. The value of T is the same across the bands within one FR, the reported T values should be separated for FR1 and FR2. |

* 1. Dependence on BW and SCS

### Round #1 (Initial Collection of Views)

In this section companies provide views on the dependence of UE DL PRS processing capability on DL PRS BW or SCS.

Companies are invited to provide views at least on the following aspects:

1. Note: It was already agreed that UE DL PRS processing capability is reported for maximum DL PRS BW supported by UE: “Duration of DL PRS symbol in units of ms a UE can process every T ms assuming maximum DL PRS bandwidth in MHz”
   * Considering the above note: does RAN1 WG need to take any additional action with respect to dependency on the BW and if yes what needs to be reflected further?
2. Whether and how UE DL PRS Processing capabilities depend on SCS?
3. Other comments

Table 3: Dependence on BW and SCS

|  |  |
| --- | --- |
| Company | Comments |
| Qualcomm | In the previous meeting an agreement was made to change an earlier agreement with regards to the assumed maximum DL PRS bandwidth for the PRS processing capability reporting. We believe that the new agreement is unclear. What has been missed in the updated agreement is that it doesn’t say for which SCS this maximum PRS bandwidth is reported. For example, if a UE reports 20 MHz as maximum bandwidth, if the SCS is 15 Khz it corresponds to ~100 PRBs, if it is 60 Khz, it corresponds to 25 PRBs. The processing requirements of a PRS depends to the number of PRBs that need to be processed and not on the number of MHz.  The UE reports DL PRS processing capability for each different SCS supported in the band. |
| Huawei/HiSilicon | We consider that if UE reports a maximum supported bandwidth in a band as the first bandwidth, UE supports all the second bandwidths below the first bandwidth with the SCS that supports the second bandwidths.  E.g. if UE supports 100MHz for a band, UE supports <=50MHz for 15kHz SCS for that band, and <=100MHz for 30kHz for that band.  In response to QC, do you suggest UE may support 50MHz for 30kHz SCS, but not 50MHz for 15kHz? That would be strange to our understanding. |
| Qualcomm2 | The (N1,N2,T) may scale for the same BW and different SCS. For example, just to consider a toy-example UE that can process 272\*12 QPSK pilots (REs) (after destaggering) within a T = 1 msec,   * At 15 Khz and 50 Mhz, it can do 1 PRS resource (comb-X/X-symbols corresponds to 272\*12 REs after destaggering) * At 30 Khz and 50 Mhz, it can do 2 PRS resources   So, if there is no dependency on the SCS, the above UE would have to say it can only do 1 PRS resource for 50 Khz FR1 band, whereas in the reality if the SCS is 30 KHz, it could have done 2 PRS resources.  Another reason that this scaling is needed is related to the search window. Specifically, and just to show a FR2 example, the FR2 expectedRSTD-uncertainty is limited to +/- 8 usec, i.e. a total search window spanning 2\*8sec = 16 usec. So, for 60 Khz, this would correspond to +- 1 symbol, and for 120 Khz, it would correspond to +-2 symbols. Therefore, in the worst case expectedRSTDUncertainty search window, a UE may need to process/buffer significantly more OFDM symbols in 120 KHz, than in 60 Khz for the same PRS resource configuration. So, a UE would have to be able to say how much buffering/processing it can do assuming 120 Khz and 60 KHz separately assuming the maximum BW for each case (which is 264 PRBs for both). |
| Nokia/NSB | We don’t see the need to report this per SCS. QC is already proposing that the UE signal (N1, N2, T). The UE will report this for each SCS too? We are overly complicating this reporting in our view and adding complexity without clear gain. The UE needs to report a maximum processing capability and as HW points out this should then apply for lower BW/SCS. |
| Qualcomm3 | Please see my reply above. If the relation to SCS is not obvious from my reply, then we can just go back to definining under the assumption of max BW in PRBs and not in MHz. This change happened only because the agreement was saying “272 PRbs”, whereas in some bands, the maximum was “264 PRBs”.  The new agreement, without the dependency in SCS is problematic, and we prefer to go back to the previous formulation that the UE reports the maximum BW in PRBs, in which case the reporting for different SCS may not be needed. |
| CATT | We understand PRS processing capability depends on SCS. Thus, it is fine that the reported UE DL PRS Processing capabilities depend on SCS. |
| OPPO | There is no need to report per SCS. With the definition of “duration of DL PRS symbol in units of ms a UE can process every T ms assuming maximum DL PRS bandwidth in MHz”, the processing capability seem to be same for different SCS.  However, if the definition of max BW is not in MHz, but changed to the number of PRBs, then SCS shall be considered. |
| Vivo | Our preference is to have UE capability report being agnostic to SCS. We believe it’s the motivation for those agreements made in RAN1#100-e on the definition of UE capability in terms of “duration of DL PRS symbol in units of ms a UE can process every T ms assuming maximum DL PRS bandwidth in MHz”. They are all absolute units not depends on the number of PRBs.  On the comments from Qualcomm, based on the example given in the row of Qualcomm2, seems SCS dependency issue only matters if the number of PRS resources (N2) across all TRPs is also reported. Can Qualcomm clarify whether (N1, T) report depends on SCS? |
| Qualcomm4 | To Vivo:  Lets say the UE reports 10 msec of buffering in 160 msec. In 15 KHz, that is 14\*10 = 140 PRS symbols. In 30 KHz, this would be 280 PRS symbols. The buffering is not only about time-domain waveform buffering, the UE is keeping the frequency domain samples, which have now grown since each OFDm symbol may have 272 PRBs inside. So a UE would have to keep double frequency domain samples in memory for a difference SCS.  Also, the following argument was purely related to N1:   * Another reason that this scaling is needed is related to the search window. Specifically, and just to show a FR2 example, the FR2 expectedRSTD-uncertainty is limited to +/- 8 usec, i.e. a total search window spanning 2\*8sec = 16 usec. So, for 60 Khz, this would correspond to +- 1 symbol, and for 120 Khz, it would correspond to +-2 symbols. Therefore, in the worst case expectedRSTDUncertainty search window, a UE may need to process/buffer significantly more OFDM symbols in 120 KHz, than in 60 Khz for the same PRS resource configuration. So, a UE would have to be able to say how much buffering/processing it can do assuming 120 Khz and 60 KHz separately assuming the maximum BW for each case (which is 264 PRBs for both).   And again, I want to repeat: We would be OK with the initial agreement of making as a function of max number of PRBs and keep it agnostic to SCS. It was an OK agreement, that changed wrongly with an argument that “272” is not supported in FR2.  **Can I revert the problem an ask: Why would any of the remaining companies have a concern to change to what was initially agreed: UE reports the PRS BW in Number of PRBs rather than MHz, and then keep it agnostic to SCS?** |
| Vivo2 | In response to Qualcomm:  Thanks for your answer and further explanation to our question. Your assumption about UE buffering/processing of seems tied to a way/implementation of UE buffering waveform samples. If that’s the common understanding, we’re actually OK to revert to previous RAN1#99 agreements where the UE DL processing is reported in number of PRBs. |
| Huawei/HiSilicon2 | We are not OK to revert the agreement. Please also find our reply to QC.  The (N1,N2,T) may scale for the same BW and different SCS. For example, just to consider a toy-example UE that can process 272\*12 QPSK pilots (REs) (after destaggering) within a T = 1 msec,   * At 15 Khz and 50 Mhz, it can do 1 PRS resource (comb-X/X-symbols corresponds to 272\*12 REs after destaggering) * At 30 Khz and 50 Mhz, it can do 2 PRS resources   So, if there is no dependency on the SCS, the above UE would have to say it can only do 1 PRS resource for 50 Khz FR1 band, whereas in the reality if the SCS is 30 KHz, it could have done 2 PRS resources.   * In that case, we suggest to agree the number of PRS resources in a slot as a UE capability, in which case UE would always report 1, regardless of SCS. And the total number of RE process within 1ms will be controlled by this capability as well assuming the same BW.   In summary, to echo our comments in 2.2, we propose to add a new capability for the number of PRS resources in a slot |
| Intel | We suggest not to revert agreement. The discussion may be endless overwise.  We do not see dependency on SCS of (N, T) reporting for max BW supported by UE. Regarding the number of resources, we are confused on 1 vs 2 resources for 15 vs 30kHz. When fixed values of BW and N are reported in absolute time the chunk of processed spectrum does not change. Certainly, UE can either process one symbol in case of 15kHz or two symbols (each two times shorter) in case of 30kHz. However, in our view this aspect is not about SCS dependency rather about resource configuration structure. Therefore LMF can figure out UE DL PRS processing capability. |

### Round #2 (Comments on Initial Proposal)

Based on discussion in the previous sub-section, the following proposal is suggested for further discussion.

**Proposal 3**

* **The reporting of (N, T) values for maximum BW in MHz is not dependent on SCS**

Companies are invited to comment on above proposal

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei/HiSilicon | We support this proposal if a new capability of number of PRS resources per slot is introduced. |
| Qualcomm | Even though we have clear technical concerns, we will accept it if the UE can report **Number of PRS resources it can process within a slot per SCS of the band.** |
| Nokia/NSB | See our comments to 2.3.2. |
| CATT | We would like to understand more on the new capability of number of PRS resources and the impact on this proposal. |
| Vivo | Support. See our comments to 2.2.2. |
| Huawei/HiSilicon2 | My understanding of adding number of resources per slot is that the effective REs after de-staggering for the UE to process is generally 12 \* NRB \* Nres per slot, also 12 \* (NRB \* Nslot) \* Nres per 1ms; it does not scale w.r.t. comb size and number of symbols at least for (2,2), (4,4), (6,6), and (12,12). It may add a marginal buffering effort when it comes to (4,2), (6,2), (12,2), (12,4), (12,6).  Note that (NRB \* Nslot) does not scale with SCS, given a bandwidth. For example, given 50MHz, we have approximately 270 RB \* 1 for 15kHz, and 133 RB \* 2 for 30kHz, and 65 RB \* 4 for 60kHz. |
| Samsung | We support the PRS processing capability in the format of multiple pairs of (N1, T) assuming a max PRS bandwidth, which is reported for each SCS. The value of T is the same across the bands within one FR, the reported T values should be separated for FR1 and FR2. |

* 1. Simultaneous DL PRS processing across frequency layers

### Round #1 (Initial Collection of Views)

In this section, companies provide views on support of simultaneous DL PRS processing across multiple positioning frequency layers. It was already agreed that UE DL PRS processing capabilities are defined for a single positioning frequency layer. Therefore companies are invited to provide answer to the following questions:

1. Whether there is a need to define support of simultaneous DL PRS processing across multiple positioning frequency layers?
2. If answer to one is yes, whether and how UE DL PRS processing capabilities defined per single positioning frequency layer can be reused to define UE DL PRS processing capabilities for simultaneous processing across multiple positioning frequency layers?
3. Is there any assumption on configuration settings of DL PRS resources across multiple positioning frequency layers (DL PRS BW, SCS, etc.) for simultaneous DL PRS processing across multiple positioning frequency layer?
4. What is the reporting format for simultaneous DL PRS processing?
5. Other comments

Note: By simultaneous, it is assumed that UE is capable to process DL PRS transmitted at the same time across multiple positioning frequency layers.

Table 4: Simultaneous DL PRS processing across frequency layers

|  |  |
| --- | --- |
| Company | Comments |
| Qualcomm | For a UE supporting multiple positioning frequency layers, a UE is expected to process one frequency layer at a time. So, we don’t see the need to have a simultaneous PRS processing capability for Rel-16. |
| Huawei/HiSilicon | 1) No need. We think that it is a common understanding in RAN4, which means that the latency requirement for simultaneous processing of multiple positioning frequency layers will not be specified in RAN4 and not expected by the LMF.  2) Not applicable.  3) Not applicable.  4) Not applicable. |
| Nokia/NSB | There is no need for this in our view. |
| CATT | Share the similar understanding that we don’t see the need to define PRS processing capability for Rel-16. |
| OPPO | No, there is no need to defined the capability of simultaneous processing of multiple frequency layers. |
| Vivo | No. For RRM measurement, RAN4 requirement assumes only one frequency layer per measurement gap. We think this assumption is still applicable for positioning frequency layer. Therefore, our preference is not to introduce another UE capability of simultaneous DL PRS processing across of multiple frequency layers. |
| Intel | We are fine to not introduce this capability. If it is not introduced for NR, we also do not see the need to define simultaneous processing of LTE PRS and NR PRS by different RATs on different bands. It should be left up to UE implementation as well. |

### Round #2 (Comments on Initial Proposal)

Based on discussion in the previous sub-section, it seems companies prefer not to define capability for UE simultaneous DL PRS Processing, therefore the following proposal is suggested for further discussion.

**Proposal 4**

* **UE capability for simultaneous DL PRS processing across positioning frequency layers is not supported in Rel.16 (i.e. for a UE supporting multiple positioning frequency layers, a UE is expected to process one frequency layer at a time)**

Companies are invited to comment on above proposal

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei/HiSilicon | Support. |
| Qualcomm | OK |
| Nokia/NSB | Support. |
| CATT | Support |
| vivo | Support |
| Samsung | Support |

* 1. UE DL PRS processing capabilities w/ and w/o measurement gap

### Round #1 (Initial Collection of Views)

In this section, companies provide views whether to define UE DL PRS processing capabilities for the cases with and w/o measurement gap configured.

1. Whether there is a need to define UE DL PRS processing capabilities for the case w/o measurement gap configured and if so, why it is needed?
2. If answer to 1) is yes, what is the difference that needs to be reflected comparing to the case when measurement gap is configured. Is there any change in assumption on UE max DL PRS processing BW, etc.?

Table 5: UE DL PRS processing capabilities with and w/o measurement gap

|  |  |
| --- | --- |
| Company | Comments |
| Qualcomm | Yes it needs to be reported separately for MG configured and MG not configured.  We make the following observations with regards to PRS processing:   * During measurement gaps, the UE is not processing any other DL signal except PRS * The UE would likely not have dedicated RF and BaseBand (BB) resources just for PRS processing. In other words, the available memory budgets / CPU processing capabilities are being shared between DL PRS and other functions of the UE.   Based on the above 2 basic principles, it is evident that during a measurement gap, a UE would have more buffering/processing resources to dedicate for PRS processing compared to the case outside measurement gaps.  There was a comment that the duration of MGs is much lower than the periodicity of PRS (e..g, 5 msec out of 160 msec), and that such differentiation would be useful only for the case of “real-time processing Ues” which “is likely to be implemented in Rel-16”. We respectfully disagree in both arguments:   * RAN4 is discussing the addition of longer MGs in Rel-16. * Even if not new MGs are added, we think that “real-time processing” should not be precluded as an implementation, in which case a UE may be doing significantly processing within the MGs. * Rel-16 has added PRS periodicities as small as a few msec.   In some cases, a UE may not even be able to process any PRS outside measurement gaps. For example, in FR2, a UE may be required to do a different Beam management procedure compared to PDSCH/PDCCH/CSIRS which can only be happening inside measurement gaps, because this is where there are scheduling restrictions. |
| Huawei/HiSilicon | 1) No need. Based on the comment from QC, our view seems to be mis-interpreted by QC. Our view is that the processing capability assuming measurement gap should be prioritized in this release. Reporting capability without MGs does not help much.  Also upon receiving assistance data, UE may decide whether or not request measurement gap. LMF does not know whether UE requests the MG, as MG is requested from the serving cell, and the serving cell will not provide any information to the LMF.  2) Not applicable. |
| Qualcomm2 | Is HW/HiSi considering that PRS would not be configured without MGs in both FR1/FR2? If that is the reason they consider the UE should not report PRS processing capabilities without MGs, then it should be stated that way.  If the UE does not report different capabilities, then for sure there is no way the LMF to know. If the UE reports both, it would at least know whether the configured assistance data would be within the first or second report capabilities and make a decision what the PRS measurement latency would be in the worst case. Also RAN2/RAN3 signaling is still in early stages.  Not sure if the intention from HW/HiSi is to remove the feature of PRS processing without MGs from Rel-16 for both FR1/FR2, or just remove the related capability reporting. |
| Nokia/NSB | We really don’t see the need to define capabilities for both w/ and w/o measurement gaps. |
| CATT | We understand UE may have different DL PRS processing capability for the scenarios with MG and without MG if the UE is required to process other DL signals/data. For R16, we are fine only to define the DL PRS processing capability based on the assumption the MG is configured, and UE does not need to handle DL traffic data. |
| OPPO | Yes, the UE capability shall be defined for with MG and without MG separately. If we can clarify the UE capability with the assumption that MG is configured, that is ok too.  From our understanding, UE has different behavior in these two different cases and thus processing capability are different. |
| Vivo | We acknowledge there might be difference in terms of UE internal DL PRS processing capability for with and without measurement gap configuration.  However, whether to configure measurement gap for a UE is determined by the serving gNB. Even if this UE processing capability with/without gap is provided to the LMF, the LMF cannot determine the corresponding assistant data as whether a UE is configured with a measurement gap is unknown to the LMF. Throughout the whole Rel-16 positioning discussion, there’s no assumption that measurement gap configuration for UE would be available to LMF.  So we think there is no need to separate this capability for the case with or without gap configuration. |
| Qualcomm3 | RAN4 will put requirements accordingly, which would result to different PRS latency for either case. So, it is about UE meeting accuracy requirements within a reasonable PRS latency time.  Is vivo/Nokia assuming that the UE would be reporting the PRS processing capabilities assuming worst case scenario? This would really underreport UE capabilities and we have strong concerns for this, especially if it is not clear under for which scenario the UE is reporting capabilities. |
| Vivo2 | In response to Qualcomm:  Similar to Huawei/CATT, our view is actually the UE DL PRS processing capability assuming measurement gap is prioritized in Rel-16.  If the concern is about for which scenario the UE is reporting capabilities, a note in UE capability table is sufficient. Our argument is not to define separate UE capability which cannot be used by LMF. |
| Huawei/HiSilicon2 | In response to Qualcomm2: We suggest to only keep the capability reporting assuming MG is available. LMF would assume the processing at UE side is based on with MG, and if in reality UE can carry out the measurement without MG, UE simply does not request MG from the gNB; otherwise, UE requests MG. |
| Intel | Our preference is to simplify framework and introduce capability only for the case when MG is configured. For the case w/o MG there are quite many uncertainties that may be challenging even to test. In addition, LMF has no idea on DL BWP settings of the UE and thus max DL PRS processing BW. It also unaware about other DL processing activities at UE side. We find this discussion quite complicated and recommend deprioritizing it at least in R16 framework. |

### Round #2 (Comments on Initial Proposal)

It seems majority of companies do not see much value and cannot accept support of UE DL PRS processing capability for the case when MG is not configured. Therefore, the proposal is to define such capability only for the case when MG is configured.

Based on discussion in the previous sub-section, the following proposal is suggested for further discussion.

**Proposal 5**

* **UE capability for DL PRS processing is defined only for the case of configured measurement gap**

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| **Company** | **Comments** |
| Huawei/HiSilicon | We suggest to revise the wording since when UE report its capability, there is no PRS configuration or MG configuration.  UE capability for DL PRS processing is defined assuming the case with configured measurement gap. |
| Qualcomm | Even though we have clear technical concerns, we will accept it if the UE can report Number of PRS resources it can process within a slot per SCS of the band. |
| Nokia/NSB | See our comments to 2.3.2. We can accept this if the number of (N,T) pairs the UE can report is limited to a reasonable number. |
| CATT | It is fine to us. Maybe with some rewording, e.g., suggested by HW. |
| vivo | Support with Huawei/HiSilicon’s wording. |
| Samsung | Fine with HW’s wording. |

1. Revised Proposals

Based on discussion in section 2 and aiming to accommodate comments from all companies, the revised proposals are formulated. Companies are invited to further provide comments on revised proposals.

One clarification seems still needed for the Note in Proposal 1.

What is assumed by UE with respect to nr-DL-PRS-ExpectedRSTD, nr-DL-PRS-ExpectedRSTD-Uncertainty values when UE reports DL PRS processing capability.

**Proposal #1**

* For the purpose of DL PRS processing capability and report, the duration of DL PRS symbols (*K*) in ms within any *P* msec window, is calculated by
  + where,
    - is the set of slots within the *P* msec window in the positioning frequency layer that contains potential DL PRS resources
    - is smallest interval in ms within slot corresponding to an integer number of OFDM symbols of a serving cell that covers the union of the potential PRS symbols and determines the PRS symbol occupancy within slot .
      * Interval considers the actual nr-DL-PRS-ExpectedRSTD, nr-DL-PRS-ExpectedRSTD-Uncertainty provided for each pair of DL PRS Resource Sets (target and reference)
* Notes:
  + UE is not expected to report capability for different DL PRS configurations. DL PRS configuration assumed by UE for capability reporting is left up to UE implementation.

**Proposal #2**

* For UE DL PRS processing capability,
* UE reports one combination of (N, T) values per band, where N is a duration of DL PRS symbols in ms processed every T ms for a given maximum bandwidth (B) in MHz supported by UE
  + Additionally UE reports new parameter – number of DL PRS resources that UE can process in a slot, which is reported per SCS. Values {1, 2, 4, 8, 16, 32, 64}
    - Note: it is up to UE implementation to decide which comb-factor and number of symbols per resource is assumed
* The following sets of values for N, T and B are supported
* Values for N = {0.125, 0.25, 0.5, 1, 2, 4, 8, 12, 16, 20, 25, 30, 35, 40, 45, 50} ms
* Values for T = {8, 16, 20, 30, 40, 80, 160, 320, 640, 1280} ms
* Values for maximum BW reported by UE = {5, 10, 20, 40, 50, 80, 100, 200, 400} MHz

**Proposal 3**

* The reporting of (N, T) values for maximum BW in MHz is not dependent on SCS

**Proposal 4**

* UE capability for simultaneous DL PRS processing across positioning frequency layers is not supported in Rel.16 (i.e. for a UE supporting multiple positioning frequency layers, a UE is expected to process one frequency layer at a time)

**Proposal 5**

* UE capability for DL PRS processing is defined assuming the case with configured measurement gap.

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| **Company** | **Comments** |
| Huawei/HiSilicon | Support P1 to P5.  There is a typo: should be |
| Qualcomm | We are generally supportive to take the above proposals together as a Way Forward to conclude this discussion. One suggestion on Proposal 1:   * UE reports new parameter – number of DL PRS resources that UE can process in a slot, which is reported per SCS **per band** |
| Nokia/NSB | On P1, we are okay in principle, but we are a bit confused by the sub-bullets and notes. It is proposed that UE “considers the actual nr-DL-PRS-ExpectedRSTD, nr-DL-PRS-ExpectedRSTD-Uncertainty provided for each pair of DL PRS Resource Sets (target and reference)”. Yet then we say, “UE is not expected to report capability for different DL PRS configurations.” How can both of these statements hold at the same time?  On P2, again in principle we are okay overall, but the note is a bit confusing to us. If the network doesn’t know what the UE assumed, then how can it use this information? For example, if UE assumes comb-2 with 2 symbols it may be able to process a larger amount of resources within one slot compared with comb-12, 12 symbols. Shouldn’t we have some baseline?  P3-P5: support. |
| Huawei/HiSilicon2 | [v24] We are Ok with QC’s revision.  Reply to Nokia  P1: We do not see them contradictory. Here is the explanation.  “UE is not expected to report capability for different DL PRS configurations.” 🡪 This is related to UE report its capability (N, T), prior to receiving any PRS configuration, when UE does not need to assume any hypothetical PRS configuration at all, and simply reports (N, T) based on its hardware budget.  “considers the actual nr-DL-PRS-ExpectedRSTD, nr-DL-PRS-ExpectedRSTD-Uncertainty provided for each pair of DL PRS Resource Sets (target and reference)” 🡪 This is related to when the PRS configuration is available UE/LMF evaluates whether the configuration (K, P) is within UE reported capability (N, T), i.e. determine if K<=N, and P>=T. Hopefully that clarifies.  P2: The total number of REs after destaggering is only related to the number of resources, independent of the comb size. As for comb-2, 2 symbols will have 12 \* NRB REs, while for comb-12, 12 symbols will have 12 \* NRB REs, and thus for a single resource, the total number of REs stays the same. Therefore, we do not expect the number of resources to process in a slot will be significantly different between comb sizes. But if you consider comb-2 with 2 symbols and comb-2 with 12 symbols, perhaps the number of resources per slot may be different, in which case UE may report conservative numbers to allow for the worst case scenario. |
| Nokia/NSB\_2 | Reply to Huawei:  P1: Okay that is clearer now and we are okay to agree.  P2: We agree that the total number of REs is not changed but the number of resources per slot could change based on the assumption from UE as the number that fit in one slot (e.g., for 12 symbols only one resource fits per slot). If we assume that regardless of the comb size the UE considers the full RE grid is used (e.g., full use of FDM multiplexing from comb structure) then I think we are aligned. Is that correct? |
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1. Summary
2. Conclusions
3. References
4. TBD