**3GPP TSG RAN WG1 #100bis-E R1-2002708**

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

**Source: Moderator (Intel Corporation)**

**Title: FL Summary 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 proposals and corrections for the DL PRS design based on the submitted contributions [1] - [11].

1. Overview of Proposed Corrections

Review of Aspects Raised in [1]

In [1], the following list of open aspects is discussed,

* #1-1: DL PRS duration in slot - How to count PRS duration in slot

1. It is proposed that PRS duration is a set of consecutive symbols within the slot that covers PRS symbols from all TRPs, where the PRS symbols from each TRP is associated with an nr-DL-PRS-ExpectedRSTD and nr-DL-PRS-ExpectedRSTD-Uncertainty.

* #1-2: DL PRS duration across slots - PRS duration across slots for the same periodicity across PRS resource sets.

1. Two PRS Resource sets are configured per TRP per frequency layer with the same periodicity. It is proposed to define minimum set of continuous slots that includes one PRS occasion for each PRS resource set of all TRPs on the positioning frequency layer.

* #1-3: Periodicity across PRS resource sets

1. It is proposed to align periodicity across all PRS resource sets within frequency layer and update RAN2 and RAN4.

* #1-4: TP for #1-1, #1-2, #1-3

1. The corresponding TP for issues #1-1, 1-2, 1-3 is provided

* #1-5: Alignment of number of resources for PRS duration - Alignment of parameters N2 and X7 in UE DL PRS processing capabilities

1. Number of resources within a PRS duration. It is proposed to align assumption on Max number of Resources per frequency layer (X7) and number of resources N2 for DL PRS processing capability

* #1-6: Reporting (N,T)pairs

1. Support reporting of multiple (N, T) pairs in UE DL PRS processing capability

* #1-7: T values for DL PRS processing

1. T values across positioning frequency layers and its scaling in UE DL PRS processing capability

* #1-8: Dependence on BW

1. Duration does not scale with the BW in UE DL PRS processing capability

* #1-9: Capability w and w/o MG

1. Do not introduce separate UE DL PRS processing capabilities for the case with measurement gap and without measurement gap.

**Feature lead comments:**

* **It seems all aspects and proposals in [1] are mainly focused on UE DL PRS processing capability discussion**
  + **TBD if it can be handled under AI 7.2.8.1**

Review of Aspects Raised in [2]

In [2], the following aspects are discussed

* #2-1: PRS/SSB collision:

1. TP to address collisions between DL PRS and SS/PBCH block

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| the symbol is not used by any SS/PBCH block used by the serving cell for downlink PRS transmitted from the serving cell or not used by any SS/PBCH block used by the same non-serving cell indicated by the higher-layer parameter *SSB-positionInBurst* for downlink PRS transmitted from a non-serving cell; |

* #2-2: Alignment w/ RAN2: Configurations of periodicity and slot offset for DL PRS resource set

1. Alignment w/ RAN2 spec for parameter *DL-PRS-ResourceSetSlotOffset (NR-DL-*PRS*-Periodicity-and-ResourceSetSlotOffset)*;

**Feature lead comments:**

* **#2-1 similar proposal is made in [3] (please refer to #3-2 below). Need to discuss consolidated version**
* **#2-2 can be resolved based on R1-2002288**

Review of Aspects Raised in [3]

The following aspects are discussed in [3]:

* #3-1: Missing value: TP to capture additional value in DL PRS muting pattern in TS38.211.
* #3-2: PRS/SSB collision: Collision of DL PRS and SSB in neighbor cells.

1. Addresses the same issue as in [2] with different wording.

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| - the symbol is not used by any SS/PBCH block used by the serving cell for downlink PRS transmitted from the serving cell or any SS/PBCH block from a non-serving cell indicated by the higher-layer parameter *SSB-positionInBurst* for downlink PRS transmitted from ~~a~~ the same non-serving cell; |

* #3-3: UE DL PRS Processing Capability:

1. Maximum BW for DL PRS processing supported by UE (proposes set of values [20MHz, 50MHz, 100MHz, 200MHz, 400MHz]) and scaling consideration for DL PRS processing capability
2. UE DL PRS processing capability is agnostic to the configured SCS settings of DL PRS
3. Reported values of T should be the same across different bands.
4. UE capability of simultaneous processing of multiple frequency layers is not supported
5. No need to separate UE processing capability for scenario with or without measurement gap.

**Feature lead comments:**

* **#3-1 seems correction is needed**
* **#3-2 similar issue is proposed in [2]. Need to discuss consolidated version**
* **#3-3 relevant to UE capability discussion**
  + **TBD if it can be handled under AI 7.2.8.1**

Review of Aspects Raised in [4]

The following aspects are discussed in [4]:

* #4-1: Periodicity in slots (TPs to the TS 38.211):

1. Correction of the periodicity values of a DL PRS resource to be aligned with TS 38.214 and TS 37.355

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| <Text omitted>  For a downlink PRS resource in a downlink PRS resource set, the UE shall assume the downlink PRS resource being transmitted when the slot and frame numbers fulfil  <Text omitted>  - is bit in the bitmap given by the higher-layer parameter *DL-PRS-MutingPattern* where is the size of the bitmap;  - is bit in the bitmap given by the higher-layer parameter *DL-PRS-MutingPattern;*  <Text omitted>  the periodicity is given by the higher-layer parameter  *dl-PRS-Periodicity-and-ResourceSetSlotOffset-r16*;  <Text omitted> |

* #4-2: Different variables for muting description in TS 38.211
* #4-3: Alignment w/ RAN2 spec

1. Update the description to match the DL PRS muting configuration of TS 37.355

* #4-4: Clarification

1. Relationship b/w number of symbols and comb factor (TPs to the TS 38.214).

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| *DL-PRS-NumSymbols* defines the number of symbols of the DL PRS resource within a slot where the allowable values are given in Clause 7.4.1.7.1 of [4, TS38.211]. For the combination of {number of symbols, comb size} for a PRS resource, the UE can be configured with one of { 2, 2},{ 4, 2}, { 6, 2}, { 12, 2}, { 4, 4}, { 12, 4}, { 6, 6}, { 12, 6} and { 12, 12} |

#4-5: Corrections of the DL PRS configuration parameters:

1. Correction of the description on positioning frequency layer, DL PRS resource set, DL PRS resource in Section 7.4.1.7 TS 38.214 accordingly.

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| **In TS 38.211 Section 7.4.1.7**  *<omitted text>*  A positioning frequency layer consists of one or more PRS resource sets and it is defined by:  *- DL-PRS-SubcarrierSpacing* defines the subcarrier spacing for the DL PRS resource. All DL PRS Resources and DL PRS Resource sets in the same DL-PRS-PositioningFrequencyLayer have the same value of *DL-PRS-SubcarrierSpacing*. The supported values of DL-PRS-SubcarrierSpacing are given in Table 4.2-1 of [4, TS38.211].  *- DL-PRS-CyclicPrefix* defines the cyclic prefix for the DL PRS resource. All DL PRS Resources and DL PRS Resource sets in the same DL-PRS-PositioningFrequencyLayer have the same value of *DL-PRS-CyclicPrefix.* The supported values of *DL-PRS-CyclicPrefix* are given in Table 4.2-1 of [4, TS38.211].  *- DL-PRS-PointA* defines the absolute frequency of the reference resource block. Its lowest subcarrier is also known as Point A. All DL PRS resources belonging to the same DL PRS Resource Set have common Point A and all DL PRS Resources sets belonging to the same DL-PRS-PositioningFrequencyLayer have a common Point A.  *- dl-PRS-CombSizeN-r16* defines the comb size of a DL PRS resource where the allowable values are given in Clause 7.4.1.7.1 of [TS38.211].  *- dl-PRS-ResourceBandwidth-r16* defines the number of resource blocks configured for PRS transmission. The parameter has a granularity of 4 PRBs with a minimum of 24 PRBs and a maximum of 272 PRBs.  *- dl-PRS-StartPRB-r16* defines the starting PRB index of the DL PRS resource with respect to reference Point A, where reference Point A is given by the higher-layer parameter *DL-PRS-PointA*. The starting PRB index has a granularity of one PRB with a minimum value of 0 and a maximum value of 2176 PRBs.  The UE expects that it will be configured with [IDs] each of which is defined such that it is associated with multiple DL PRS Resource Sets from the same cell. The UE expects that one of these [IDs] along with a *DL-PRS-ResourceSetId* and a *DL-PRS-ResourceId* can be used to uniquely identify a DL PRS Resource.  A DL PRS resource set consists of one or more DL PRS resources and it is defined by:  *- DL-PRS-ResourceSetId* defines the identity of the DL PRS resource set configuration.  *- dl-PRS-ResourceList-r16* determines the DL PRS resources that are contained within one DL PRS resource set.  *- DL-PRS-Periodicity* defines the DL PRS resource periodicity and takes values slots, where for *DL-PRS-SubcarrierSpacing*=15, 30, 60 and 120kHz respectively. All the DL PRS resources within one DL PRS resource set are configured with the same DL PRS periodicity.  *- DL-PRS-ResourceRepetitionFactor* defines how many times each DL-PRS resource is repeated for a single instance of the DL-PRS resource set and takes values ,. All the DL PRS resources within one resource set have the same *ResourceRepetitionFactor*  *- DL-PRS-ResourceTimeGap* defines the offset in number of slots between two repeated instances of a DL PRS resource with the same *DL-PRS-ResourceID* within a single instance of the DL PRS resource set and takes values . The UE only expects to be configured with *DL-PRS-ResourceTimeGap* if *DL-PRS-ResourceRepetitionFactor* is configured with value greater than 1. The time duration spanned by one instance of a *DL-PRS-ResourceSet* is not expected to exceed the configured value of *DL-PRS-Periodicity*. All the DL PRS resources within one resource set have the same *DL-PRS-ResourceTimeGap.*  *- dl-PRS-NumSymbols-r16* defines the number of symbols of the DL PRS resource within a slot where the allowable values are given in Clause 7.4.1.7.1 of [4, TS38.211]. *- dl-PRS-MutingPatternList-r16* defines up to two bitmaps of the time locations where the DL PRS resource is expected to not be transmitted for a DL PRS resource set. The bitmap size can be {2, 4, 6, 8, 16, 32} bits long. each bit in the bitmap given by *mutingOption1-r16* corresponds to a configurable number provided by higher layer parameter *DL-PRS.MutingBitRepetitionFactor* of consecutive instances of a *DL-PRS-ResourceSet* where all the *DL-PRS-Resources* within the set are muted for the instance that is indicated to be muted. each bit in the bitmap given by *mutingOption2-r16* corresponds to a single repetition index for each of the *DL-PRS-Resources* within each instance of a *DL-PRS-ResourceSet* and the length of the bitmap is equal to *DL-PRS-ResourceRepetitionFactor*. Both options may be configured at the same time in which case the logical AND operation is applied to the bit maps as described in clause 7.4.1.7.4 of [4, TS 38.211].  *- DL-PRS-SFN0-Offset* defines the time offset of the SFN0 slot 0 for the transmitting cell with respect to SFN0 slot 0 of [FFS in RAN2].  *- DL-PRS-ResourceSetSlotOffset* defines the slot offset with respect to SFN0 slot 0 and takes values .  *-*  A DL PRS resource is defined by:  *- DL-PRS-ResourceId* determines the DL PRS resource configuration identity. All DL PRS resource IDs are locally defined within a DL PRS resource set.  *- DL-PRS-SequenceId* is used to initialize cinit value used in pseudo random generator [4, TS38.211, 7.4.1.7.2] for generation of DL PRS sequence for a given DL PRS resource.  *- DL-PRS-ReOffset* defines the starting RE offset of the first symbol within a DL PRS resource in frequency. The relative RE offsets of the remaining symbols within a DL PRS resource are defined based on the initial offset and the rule described in Clause 7.4.1.7.3 of [4, TS38.211].  *- DL-PRS-ResourceSlotOffset* determines the starting slot of the DL PRS resource with respect to corresponding *DL-PRS-ResourceSetSlotOffset*  *- DL-PRS-ResourceSymbolOffset* determines the starting symbol of the DL PRS resource within the starting slot.  *- DL-PRS-QCL-Info* defines any quasi-colocation information of the DL PRS resource with other reference signals. The DL PRS may be configured to be 'QCL-Type-D' with a DL PRS or SS/PBCH Block from a serving cell or a non-serving cell. The DL PRS may be configured to be 'QCL-Type-C' with a SS/PBCH Block from a serving or non-serving cell. If the DL PRS is configured as both 'QCL-Type-C' and 'QCL-Type-D' with a SS/PBCH Block then the SSB index indicated should be the same.  *<omitted text>* |

#4-6: Corrections of the PRS reception procedure in TS the 38.214

1. TRP should be used instead of cell
2. DL-PRS-ResourceSymbolOffset not only determines the starting symbol of the DL PRS resource within the starting slot, but also that within the other slot used for transmission.
3. SS/PBCH Blocks with the same SSB index may be from the same beam, or may be from different beams, since SS/PBCH block with the same SSB index may be from different servicing cells
4. The condition “as long as the condition that the DL PRS resources used belong to a single DL PRS resource set is met” should refer to the case with different DL PRS resource rather than different LD PRS resource sets

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| **In TS 38.214 Section 5.1.6.5**  *<omitted text>*  5.1.6.5 PRS reception procedure  The UE can be configured with one or more DL PRS resource set configuration(s) as indicated by the higher layer parameters *DL-PRS-ResourceSet* and *DL-PRS-Resource*. Each DL PRS resource set consists of K≥1 DL PRS resource(s) where each has an associated spatial transmission filter~~.~~ The UE can be configured with one or more DL PRS Positioning Frequency Layer configuration(s) as indicated by the higher layer parameter *DL-PRS-PositioningFrequencyLayer.* A DL PRS Positioning Frequency Layer is defined as a collection of DL PRS Resource Sets which have common parameters configured by *DL-PRS-PositioningFrequencyLayer*.  The UE assumes that the following parameters for each DL PRS resource(s) are configured via higher layer parameters *DL-PRS-PositioningFrequencyLayer, DL-PRS-ResourceSet* and *DL-PRS-Resource*.  A positioning frequency layer consists of one or more PRS resource sets and it is defined by:  *- DL-PRS-SubcarrierSpacing* defines the subcarrier spacing for the DL PRS resource. All DL PRS Resources and DL PRS Resource sets in the same DL-PRS-PositioningFrequencyLayer have the same value of *DL-PRS-SubcarrierSpacing*. The supported values of DL-PRS-SubcarrierSpacing are given in Table 4.2-1 of [4, TS38.211].  *- DL-PRS-CyclicPrefix* defines the cyclic prefix for the DL PRS resource. All DL PRS Resources and DL PRS Resource sets in the same DL-PRS-PositioningFrequencyLayer have the same value of *DL-PRS-CyclicPrefix.* The supported values of *DL-PRS-CyclicPrefix* are given in Table 4.2-1 of [4, TS38.211].  *- DL-PRS-PointA* defines the absolute frequency of the reference resource block. Its lowest subcarrier is also known as Point A. All DL PRS resources belonging to the same DL PRS Resource Set have common Point A and all DL PRS Resources sets belonging to the same DL-PRS-PositioningFrequencyLayer have a common Point A.  The UE expects that it will be configured with [IDs] each of which is defined such that it is associated with one or two DL PRS Resource Sets associated with the same *trp-ID-r16*. The UE expects that one of these [IDs] along with a *DL-PRS-ResourceSetId* and a *DL-PRS-ResourceId* can be used to uniquely identify a DL PRS Resource.  A DL PRS resource set consists of one or more DL PRS resources and it is defined by:  *- DL-PRS-ResourceSetId* defines the identity of the DL PRS resource set configuration.  *- DL-PRS-Periodicity* defines the DL PRS resource periodicity and takes values slots, where for *DL-PRS-SubcarrierSpacing*=15, 30, 60 and 120kHz respectively. All the DL PRS resources within one DL PRS resource set are configured with the same DL PRS periodicity.  *- DL-PRS-ResourceRepetitionFactor* defines how many times each DL-PRS resource is repeated for a single instance of the DL-PRS resource set and takes values ,. All the DL PRS resources within one resource set have the same *ResourceRepetitionFactor*  *- DL-PRS-ResourceTimeGap* defines the offset in number of slots between two repeated instances of a DL PRS resource with the same *DL-PRS-ResourceID* within a single instance of the DL PRS resource set and takes values . The UE only expects to be configured with *DL-PRS-ResourceTimeGap* if *DL-PRS-ResourceRepetitionFactor* is configured with value greater than 1. The time duration spanned by one instance of a *DL-PRS-ResourceSet* is not expected to exceed the configured value of *DL-PRS-Periodicity*. All the DL PRS resources within one resource set have the same *DL-PRS-ResourceTimeGap.*  *- DL-PRS-MutingPattern* defines a bitmap of the time locations where the DL PRS resource is expected to not be transmitted for a DL PRS resource set. The bitmap size can be {2, 4, 6, 8, 16, 32} bits long. The bitmap has two options for applicability. In the first option each bit in the bitmap corresponds to a configurable number provided by higher layer parameter *DL-PRS.MutingBitRepetitionFactor* of consecutive instances of a *DL-PRS-ResourceSet* where all the *DL-PRS-Resources* within the set are muted for the instance that is indicated to be muted. In the second option each bit in the bitmap corresponds to a single repetition index for each of the *DL-PRS-Resources* within each instance of a *DL-PRS-ResourceSet* and the length of the bitmap is equal to *DL-PRS-ResourceRepetitionFactor*. Both options may be configured at the same time in which case the logical AND operation is applied to the bit maps as described in clause 7.4.1.7.4 of [4, TS 38.211].  *- DL-PRS-SFN0-Offset* defines the time offset of the SFN0 slot 0 for the transmitting cell with respect to SFN0 slot 0 of [FFS in RAN2].  *- DL-PRS-ResourceSetSlotOffset* defines the slot offset with respect to SFN0 slot 0 and takes values .  *- DL-PRS-CombSizeN* defines the comb size of a DL PRS resource where the allowable values are given in Clause 7.4.1.7.1 of [TS38.211]. All DL PRS resource sets belonging to the same positioning frequency layer have the same value of *DL-PRS-combSizeN*.  *- DL-PRS-ResourceBandwidth* defines the number of resource blocks configured for PRS transmission. The parameter has a granularity of 4 PRBs with a minimum of 24 PRBs and a maximum of 272 PRBs. All DL PRS resources sets within a positioning frequency layer have the same value of *DL-PRS-ResourceBandwidth*.  *- DL-PRS-StartPRB* defines the starting PRB index of the DL PRS resource with respect to reference Point A, where reference Point A is given by the higher-layer parameter *DL-PRS-PointA*. The starting PRB index has a granularity of one PRB with a minimum value of 0 and a maximum value of 2176 PRBs. All DL PRS Resource Sets belonging to the same Positioning Frequency Layer have the same value of Start PRB.  A DL PRS resource is defined by:  *- DL-PRS-ResourceList* determines the DL PRS resources that are contained within one DL PRS resource set.  *- DL-PRS-ResourceId* determines the DL PRS resource configuration identity. All DL PRS resource IDs are locally defined within a DL PRS resource set.  *- DL-PRS-SequenceId* is used to initialize cinit value used in pseudo random generator [4, TS38.211, 7.4.1.7.2] for generation of DL PRS sequence for a given DL PRS resource.  *- DL-PRS-ReOffset* defines the starting RE offset of the first symbol within a DL PRS resource in frequency. The relative RE offsets of the remaining symbols within a DL PRS resource are defined based on the initial offset and the rule described in Clause 7.4.1.7.3 of [4, TS38.211].  *- DL-PRS-ResourceSlotOffset* determines the starting slot of the DL PRS resource with respect to corresponding *DL-PRS-ResourceSetSlotOffset*  *- DL-PRS-ResourceSymbolOffset* determines the starting symbol of the DL PRS resource within the slot.  *- DL-PRS-NumSymbols* defines the number of symbols of the DL PRS resource within a slot where the allowable values are given in Clause 7.4.1.7.1 of [4, TS38.211].  *- DL-PRS-QCL-Info* defines any quasi-colocation information of the DL PRS resource with other reference signals. The DL PRS may be configured to be 'QCL-Type-D' with a DL PRS or SS/PBCH Block from a serving cell or a non-serving cell. The DL PRS may be configured to be 'QCL-Type-C' with a SS/PBCH Block from a serving or non-serving cell. If the DL PRS is configured as both 'QCL-Type-C' and 'QCL-Type-D' with a SS/PBCH Block then the SSB index indicated should be the same and should be from the same cell.  The UE assumes constant EPRE is used for all REs of a given DL PRS resource.  The UE may be indicated by the network that a DL PRS resources can be used as the reference for the DL RSTD, DL PRS-RSRP, and UE Rx-Tx time difference measurements in a higher layer parameter *DL-PRS-RstdReferenceInfo*. The reference time indicated by the network to the UE can also be used by the UE to determine how to apply higher layer parameters DL-PRS-expectedRSTD and DL-PRS-expectedRSTD-uncertainty. The UE expects the reference time to be indicated whenever it is expected to receive the DL PRS. This reference time provided by *DL-PRS-RstdReferenceInfo* may include an [ID], a PRS resource set ID, and optionally a single PRS resource ID or a list of PRS resource IDs. The UE may use different DL PRS resources as long as the condition that the DL PRS resources used belong to a single DL PRS resource set is met or a different DL PRS resource set to determine the reference time for the RSTD measurement. If the UE chooses to use a different reference time than indicated by the network, then it is expected to report the [ID], the DL PRS resource ID(s) or the DL PRS resource set ID used to determine the reference.  The UE may be configured to report quality metrics corresponding to the RSTD and UE Rx-Tx time difference measurements which include the following fields:  *- TimingMeasQuality-Value* which provides the best estimate of the uncertainty of the measurement  *- TimingMeasQuality-Resolution* which specifies the resolution levels used in the *TimingMeasQuality-Value* field  The UE expects to be configured with higher layer parameter *DL-PRS-expectedRSTD*, which defines the time difference with respect to the received DL subframe timing the UE is expected to receive DL PRS, and *DL-PRS-expectedRSTD-uncertainty*, which defines a search window around the expectedRSTD.  For DL UE positioning measurement reporting in higher layer parameters *DL-PRS-RstdMeasurementInfo or DL-PRS-UE-Rx-Tx-MeasurementInfo* the UE can be configured to report the DL PRS resource ID(s) or the DL PRS resource set ID(s) associated with the DL PRS resource(s) or the DL PRS resource set(s) which are used in determining the UE measurements DL RSTD, UE Tx-Rx time difference or the DL PRS-RSRP.  The UE can be configured in higher layer parameter *UE Rx-Tx Time-MeasRequestInfo* to report multiple UE Rx-Tx time difference measurements corresponding to a single configured SRS resource or resource set for positioning. Each measurement corresponds to a single received DL PRS resource or resource set which can be in difference positioning frequency layers.  For the DL RSTD, DL PRS-RSRP, and UE Rx-Tx time difference measurements the UE can report an associated higher layer parameter *Timestamp*. The *Timestamp* can include the SFN and the slot number for a subcarrier spacing. These values correspond to the reference which is provided by *DL-PRS-RSTDReferenceInfo*.  The UE is expected to measure the DL PRS resource outside the active DL BWP or with a numerology different from the numerology of the active DL BWP if the measurement is made during a configured measurement gap. When not configured with a measurement gap, the UE is only required to measure DL PRS within the active DL BWP and with the same numerology as the active DL BWP. When the UE is expected to measure the DL PRS resource outside the active DL BWP it may request a measurement gap in higher layer parameter [XYZ].  The UE assumes that the DL PRS from the serving cell is not mapped to any symbol that contains SS/PBCH block from the serving cell. If the time frequency location of the SS/PBCH block transmissions from non-serving cells are provided to the UE then the UE also assumes that the DL PRS from a non-serving cell is not mapped to any symbol that contains the SS/PBCH block of the same non-serving cell.  The UE may be configured to report, subject to UE capability, up to 4 DL RSTD measurements per pair of *trp-ID-r16* with each measurement between a different pair of DL PRS resources or DL PRS resource sets within the DL PRS configured for those *trp-ID-r16*. The up to 4 measurements being performed on the same pair of cells and all DL RSTD measurements in the same report use a single reference timing.  The UE may be configured to measure and report up to 8 DL PRS RSRP measurements on different DL PRS resources associated with the same *trp-ID-r16*. When the UE reports DL PRS RSRP measurements from one DL PRS resource set, the UE may indicate which DL PRS RSRP measurements have been performed using the same spatial domain filter for reception.  If the UE is configured with *DL-PRS-QCL-Info* and the QCL relation is between two DL PRS resources, then the UE assumes those DL PRS resources are associated with the same *trp-ID-r16*. If *DL-PRS-QCL-Info* is configured to the UE with 'QCL-Type-D' with a source DL-PRS-Resource then the *DL-PRS-ResourceSetId* and the *DL-PRS-ResrouceId* of the source DL-PRS-Resource are expected to be indicated to the UE.  The UE does not expect to process the DL PRS in the same symbol where other DL signals and channels are transmitted to the UE when there is no measurement gap configured to the UE.  *<omitted text>* |

**Feature lead comments:**

* **#4-1 (periodicity in slots) seems needed**
* **#4-2 seems not needed**
* **#4-3 is covered by [9], that can be used as a starting point**
* **#4-4 recommend capturing clarification of relationship b/w number of symbols and comb factor in the TS 38.211**
* **#4-5 recommend handling under AI 7.2.8.4**
* **#4-6 recommend handling under AI 7.2.8.4**

Review of Aspects Raised in [5]

In [5], the following corrections are proposed:

* #5-1 Periodicity in slots + reference

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| * 7.4.1.7.4 Mapping to slots in a downlink PRS resource set   *---- Unchanged parts omitted ----*  - the periodicity slots is given by the higher-layer parameter *DL-PRS-Periodicity*;  *---- Unchanged parts omitted ----*  For a downlink PRS resource in a downlink PRS resource set configured, the UE shall assume the downlink PRS resource being transmitted as described in clause ~~5.1.6.4~~ 5.1.6.5 of [6, TS 38.214]. |

* #5-2 Amplitude scaling of PRS resource

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| * 7.4.1.7.3 Mapping to physical resources in a downlink PRS resource   For each downlink PRS resource configured, the UE shall assume the sequence  is scaled with a factor and mapped to resources elements according to  *---- Unchanged parts omitted ----*   * The UE shall assume for a PRS resource where is determined from the higher-layer parameter *dl-PRS-ResourcePower-r16* in *NR-DL-PRS-ResourceSet-r16*, and the UE should assume for a PRS resource which is configured to be muted as described in 7.4.1.7.4   *---- Unchanged parts omitted ----* |

**Feature lead comments:**

* **#5-1**
  + **Updated reference can be handled as a part of discussion on R1-2002288**
  + **Periodicity in slots – same issue was raised by [4] (see issue #4-1), needs to be addressed**
* **#5-2 does not seem to be needed**
  + **Muting part of the sentence is already described by equation for PRS transmission. Indication of** *dl-PRS-ResourcePower-r16* **is used for SRS for positioning OLPC and not necessarily for TX power settings**

Review of Aspects Raised in [6]

In [6], it is proposed that #6-1 RAN1 should clarify the value of in the absence of configuration.

**Feature lead comments:**

* **#6-1 does not seem to be a critical issue**
  + **It was discussed last meeting without consensus reached (configuration is always provided)**

Review of Aspects Raised in [7]

The following list of corrections is proposed in [7]:

* #7-1: Bitmap definition in TS 38.211 - alignment with RAN2 specification
* #7-2: Alignment with RAN2 specification - Inform RAN2 that each muting option is optional
* #7-3: Update of muting description in the TS 38.214 to align with RAN2 specification

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| 5.1.6.5 PRS reception procedure < Unchanged parts are omitted >  *- DL-PRS-MutingPattern* defines ~~a bitmap of~~ the time locations where the DL PRS resource is expected to not be transmitted for a DL PRS resource set.~~The bitmap size can be {2, 4, 6, 8, 16, 32} bits long. The bitmap~~ It has two options ~~for applicability~~. If *mutingOption1* is configured, ~~In the first option~~ each bit in the *mutingPattern* of *mutingOption1*~~bitmap~~ corresponds to a configurable number provided by higher layer parameter *DL-PRS-MutingBitRepetitionFactor* of consecutive instances of a *DL-PRS-ResourceSet* where all the *DL-PRS-Resources* within the set are muted for the instance that is indicated to be muted. The *mutingPattern* can be {2, 4, 6, 8, 16, 32} bits long. If *mutingOption2* is configured, each bit of the *mutingPattern* of *mutingOption2* ~~the second option each bit in the bitmap~~ corresponds to a single repetition index for each of the *DL-PRS-Resources* within each instance of a *DL-PRS-ResourceSet* and the length of the *mutingPattern* ~~bitmap~~ is equal to *DL-PRS-ResourceRepetitionFactor*. Both *mutingOption1* ~~options~~ and *mutingOption2* may be configured at the same time in which case the logical AND operation is applied to the bit maps as described in clause 7.4.1.7.4 of [4, TS 38.211].  < Unchanged parts are omitted > |

* #7-4: UE DL PRS Processing Capability

1. For the duration of DL PRS symbol in units of ms a UE can process every T ms, we suggest the values of T to be the same set of the values of DL PRS transmission periods.
2. UE DL PRS processing capability is agnostic to the configured SCS settings of DL PRS;
3. The reported values of T can be per band, e.g., different for different bands.
4. The processing capability is independent of the configuration of the measurement gap.

**Feature lead comments:**

* **#7-1 can be resolved as a part of discussion on R1-2002288**
* **#7-2 RAN1 to inform RAN2 that muting is optional**
* **#7-3 recommend handling under AI 7.2.8.4**
* **#7-4(a-d) seems relevant to discussion on UE capability**
  + **TBD if it can be handled under AI 7.2.8.1**

Review of Aspects Raised in [8]

In [8], the following proposals have been made:

* #8-1: Confirm the following working assumption in table

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|  | 2 symbols | 4 symbols | 6 symbols | 12 symbols |
| Comb-2 | {0,1} | {0,1,0,1} | {0,1,0,1,0,1} | {0,1,0,1,0,1,0,1,0,1,0,1} |
| Comb-4 | NA | {0,2,1,3} | NA | {0,2,1,3,0,2,1,3,0,2,1,3}} |
| Comb-6 | NA | NA | {0,3,1,4,2,5} | {0,3,1,4,2,5,0,3,1,4,2,5} |
| Comb-12 | NA | NA | NA | Working assumption: {0,6,3,9,1,7,4,10,2,8,5,11} |

* #8-2: UE DL PRS processing capability

1. UE may report the maximum PRS bandwidth BWmax and (N, T) for each SCS. The reported value for N should include the impact of cell phase synchronization error between TRPs.

* #8-3: UE DL PRS processing capability is not exactly scaled inversely proportional to DL PRS processing bandwidth
  1. Option 1: UE reports the capability corresponding to maximum PRS bandwidth to be supported. Scaling rule in Table 2 is applied to interpret UE’s capability if network configures smaller BW.
  2. Option 2: UE reports multiple PRS bandwidth values to indicate scaling boundaries.
* #8-4: When neighbour cells or BWPs employ different SCS and some of the UEs require time or energy critical PRS measurements from this cell or BWP, the lower SCS cell should be able to configure the PRS as a comb-N/µ pattern, where µ is the ratio between higher and lower SCS employed by the two respective cells/ BWPs.

**Feature lead comments:**

* **#8-1 WA is already part of specification TS 38.211 Table 7.4.1.7.3-1:**
* **#8-2 and #8-3 relate to UE capability**
  + **TBD if it can be handled under AI 7.2.8.1**
* **#8-4 Does not seem to be critical for the Rel.16**

Review of Aspects Raised in [9]

The text proposal in [9], provides the revision of the Section 7.4.1.7 in the TS 38.211, that aims alignment with RAN2 specifications on names of higher layer parameters (#9-1).

**Feature lead comments:**

* **#9-1:** 
  + **Text proposal in R1-2002288 is recommended as a starting point for discussion with the following additional actions:**
    - **Incorporate new identified editorial issues**
    - **Incorporate new TPs agreed during the RAN#100bis-E**

Review of Aspects Raised in [10]

The paper in [10], provides discussion on remaining aspects of UE DL PRS processing capabilities.

* 10-1: DL PRS processing capability. Define the DL PRS processing capabilities as:
  + 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, which is supported when measurement gaps are configured.
    - 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
  + 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, which is supported when measurement gaps are not configured.
    - 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
  + When a UE does not report this UE DL PRS processing capability, the UE does not support DL PRS processing without measurement gaps

**Feature lead comments:**

* **10-1: Discussion is relevant to UE DL PRS processing capabilities. TBD if it can be handled under AI 7.2.8.1**

Review of Aspects Raised in [11]

In [11], the following issues were discussed

* #11-1: Clarification to DL PRS muting Option 2:

1. The UE is not expected to be configured with DL PRS muting option 2 for a PRS resource with *DL-PRS-ResourceRepetitionFactor* configured with value 1.

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| 5.1.6.5 PRS reception procedure ----unchanged text is omitted --------  *- DL-PRS-MutingPattern* defines a bitmap of the time locations where the DL PRS resource is expected to not be transmitted for a DL PRS resource set. The bitmap size can be {2, 4, 6, 8, 16, 32} bits long. The bitmap has two options for applicability. In the first option each bit in the bitmap corresponds to a configurable number provided by higher layer parameter *DL-PRS.MutingBitRepetitionFactor* of consecutive instances of a *DL-PRS-ResourceSet* where all the *DL-PRS-Resources* within the set are muted for the instance that is indicated to be muted. In the second option each bit in the bitmap corresponds to a single repetition index for each of the *DL-PRS-Resources* within each instance of a *DL-PRS-ResourceSet* and the length of the bitmap is equal to *DL-PRS-ResourceRepetitionFactor*. Both options may be configured at the same time in which case the logical AND operation is applied to the bit maps as described in clause 7.4.1.7.4 of [4, TS 38.211]. The UE is not expected to be configured with DL PRS muting option 2 for a PRS resource with DL-PRS-ResourceRepetitionFactor configured with value 1.  ----unchanged text is omitted -------- |

#11-2: Differentiation of PRS/SSB collision for FR1 and FR2:

1. FR1“is not transmitted resource elements occupied by SSB transmissions of the neighbour TRP”,
2. FR2: “is not transmitted on symbols occupied by SSB transmissions of the neighbour TRP”

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| 5.1.6.5 PRS reception procedure ----unchanged text is omitted --------  For frequency range 1, the UE assumes that for the serving cell the DL PRS is not transmitted in any resource element that contains SS/PBCH. If the time frequency location of the SS/PBCH block transmissions from non-serving cells are provided to the UE then the UE also assumes that for the non-serving cell the DL PRS is not transmitted to any resource element that contains the SS/PBCH block of the non-serving cell.  For frequency range 2, ~~T~~the UE assumes that for the serving cell the DL PRS is not ~~mapped to~~transmitted in any symbol that contains SS/PBCH. If the time frequency location of the SS/PBCH block transmissions from non-serving cells are provided to the UE then the UE also assumes that for the non serving cell the DL PRS is not ~~mapped to~~transmitted in any symbol that contains the SS/PBCH block of the non-serving cell.  ----unchanged text is omitted -------- |

#11-3: Spatial transmission filter

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| 5.1.6.5 PRS reception procedure The UE can be configured with one or more DL PRS resource set configuration(s) as indicated by the higher layer parameters *DL-PRS-ResourceSet* and *DL-PRS-Resource*. Each DL PRS resource set consists of K≥1 DL PRS resource(s) ~~where each has an associated spatial transmission filter~~. |

#11-4: Fallback to cell ID for sequence generation

**Feature lead comments:**

* **11-1: #7-3 recommend handling under AI 7.2.8.4**
* **11-2: #7-3 recommend handling under AI 7.2.8.4**
* **11-3: #7-3 recommend handling under AI 7.2.8.4**
* **11-4 (same as #6-1) does not seem to be a critical issue**
  + **It was discussed last time without consensus reached (configuration can be always provided as a solution) if fallback is not agreed**

1. Summary of Issues

Based on review of contributions, all raised aspects can be categorized as follows:

* TPs with corrections to the TS 38.211:
  + Editorial and alignment w/ RAN2 #9-1, #4-3, #5-1(reference), #2-2, #7-1
    - Alignment with RAN2 specification 37.355 and editorial corrections
  + Technical #2-1, #3-1, #3-2, #4-1, #4-4, #7-2
    - PRS/SSB collision handling for neighbour cells (#2-1, #3-2)
    - Missing value in muting pattern (#3-1)
    - Periodicity in slots for DL PRS transmission (#4-1)
    - Relationship b/w number of symbols and comb factor (#4-4)
      * It is recommended to define table in TS 38.211 rather than proposed sentence in the TS 38.214
    - Inform RAN2 that muting is optional (#7-2)
* Discussion on UE DL PRS processing capability #1-1,…,#1-9, #3-3, #7-4, #8-2, #8-3, #10-1
  + How to define duration for UE DL PRS processing capabilities
  + Reporting of UE DL PRS processing capabilities and T values
  + Dependence on BW and SCS
  + Simultaneous DL PRS processing across frequency layers
  + UE DL PRS processing capabilities for the cases w/ and w/o measurement gap configured
* TPs with corrections to the TS 38.214
  + Editorial, technical, alignment w/ RAN2: #4-5, #4-6, #7-3, #11-1, #11-2, #11-3
* Non-essential/critical corrections: Others

1. Conclusion and Recommendation

This contribution provided summary of proposed corrections to the DL PRS design for NR Positioning. Based on discussion, we suggest organizing the following e-mail discussions to resolve identified opens:

* E-mail Discussion #1 – Corrections to the TS 38.211
  + Based on the following TPs #9-1, #2-2, #7-1, #2-1, #3-1, #3-2, #4-1, #4-3, #4-4, #5-1(reference #7-2)
    - Editorial and alignment w/ RAN2 #9-1, #4-3, #5-1(reference), #2-2, #7-1
      * Alignment with RAN2 specification 37.355 and editorial corrections
    - Technical #2-1, #3-1, #3-2, #4-1, #4-4, #7-2
      * PRS/SSB collision handling for neighbour cells (#2-1, #3-2)
      * Missing value in muting pattern (#3-1)
      * Periodicity in slots for DL PRS transmission (#4-1)
      * Relationship b/w number of symbols and comb factor (#4-4)
      * Inform RAN2 that muting is optional (#7-2)
* E-mail Discussion #2 – UE DL PRS processing capability (Continuation from RAN1-100E)
  + It is recommended to handle this discussion under AI 7.2.8.1 with a scope defined by #1-1,…,#1-9, #3-3, #7-4, #8-2, #8-3, #10-1:
    - How to define duration for UE DL PRS processing capabilities
    - Reporting of UE DL PRS processing capabilities and T values
    - Dependence on BW and SCS
    - Simultaneous DL PRS processing across frequency layers
    - UE DL PRS processing capabilities for the cases w/ and w/o measurement gap configured
  + Note:
    - It is up to chair to decide whether RAN1 WG can have this discussion independent from UE feature list e-mail thread
* E-mail Discussion #3 – Corrections to the TS38.214
  + Based on the following TPs #4-5, #4-6, #7-3, #11-1, #11-2, #11-3
  + Note:
    - It is recommended to handle this under AI 7.2.8.4

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| Company | Views |
| Qualcomm | Due to the fact that there can be up to one Email Discussion, and we should try to keep the scope reasonable, we prefer to prioritize **ED #2.**   * **Reasoning**: We think that there are still several details that need specific technical discussion and common understandings in the main session before moving it into the UE feature session. In the UE feature session, there are many other issues that need to be first resolved, before going into the details of each element, if any details are still missing.   With regards to ED #1, most the proposals are just alignment, editorial, and we don’t consider them as crucial when in ED #2 there are still several critical aspects not being resolved yet. If a subset of those can be considered as part of the single ED in this sub-Agenda, we would also be OK (like #4-4 for example)  With regards to E-D #3, this is the lowest priority and actually some of the items have already been discussed and concluded (like #11-2). They seem to be related to 72.8.4 also, which already have several issues included. |
| Huawei/HiSilicon | We are in general in support of the arrangement of the email discussion.  However, we may face the limit of 4 email discussions for this WI, and we wonder how to assign the email discussions across AIs. To us, it is unlikely that we are going to have one ED for fixing 211, one ED for fixing 214, and one ED for fixing SRS as the approach in the previous meeting. Any plan/guidance from the rapporteur to be disclosed beforehand would be helpful before finalizing the phase 1 scoping. |
| Samsung | We support the organization of email discussion. As mentioned by QC, we strongly suggest to prioritize ED#2. ED#1 and #3 can be merged and even dropped since they are not critical. |
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1. References
2. R1-2001558 Maintenance of DL PRS for NR positioning Huawei, HiSilicon
3. R1-2001600 Maintenance of DL reference signals for NR positioning ZTE
4. R1-2001685 Discussion on remaining issues on DL RS for NR positioning vivo
5. R1-2001731 Remaining Issues on DL Positioning Reference Signal OPPO
6. R1-2001954 Remaining details of DL Reference signals for NR positioning LG Electronics
7. R1-2002046 Remaining details on DL Reference Signals Futurewei
8. R1-2002095 Remaining issues on DL PRS for NR Positioning CATT
9. R1-2002144 DL Reference Signals for NR Positioning Samsung
10. R1-2002288 Corrections to DL reference signals for NR positioning Intel Corporation
11. R1-2002557 Discussion on DL PRS processing & related UE capabilities Qualcomm Incorporated
12. R1-2002620 Maintenance of rel16 DL reference signals for NR positioning Ericsson