**3GPP TSG RAN WG1 #101-e R1-2004416**

e-Meeting, May 25th – June 5th, 2020

Source: NTT DOCOMO, INC.

Title: Summary on Rel-16 NR TEI related discussion

Agenda Item: 7.2.12

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

# **Introduction**

This contribution summarizes the NR Rel-16 TEI related and CLI/RIM related discussions and proposals in AI 7.2.12.

Based on contributions in AI 7.2.12, following six issues are identified.

* CLI measurement and reporting [2]
* Aperiodic CSI-RS triggering with beam switching timing of 224 and 336 [5]
* Half-duplex operation in CA [1, 3, 7]
* Intermediate number of information bits [6, 9] (to be discussed under 7.1)
* TRS muting [4]
* Conditions of rate matching pattern overlapping with PDSCH DMRS symbols [8]

As a feature lead’s opinion according to the contribution reviewing, following is the suggested list of issues to be discussed and priority order. Since remaining issues for maintenance of already endorsed TEI items and CLI/RIM WI should be prioritized over other issues and considering reasonable number of email threads e.g., up to three, the feature lead thinks RAN1 should focus on following three remaining issues on CLI/RIM WI and endorsed TEI item.

**FL proposal of list of issues/proposals and priority:**

1. **Remaining issues for CLI measurement**
	* **Whether/how to capture the agreement regarding the number of antenna ports per SRS resource for SRS-RSRP measurement in TS38.214**
		+ **TP in R1-2003492 as starting point for the discussion**
2. **Remaining issues for half-duplex operation in CA**
	* **Whether/how to clarify the reference cell determination and confliction determination for deactivated SCell**
		+ **Alt.1: Clarify that the reference cell is determined based on configured set of serving cells (as TP in R1-2004259)**
		+ **Alt.2: Clarify that RRC configured DL reception and UL transmission, for a deactivated Scell are not considered for confliction determination on configured serving cells, and UE assumes all the symbols on deactivated Scell as semi-static flexible symbol for confliction determination on configured serving cells (as TP in R1-2003423)**
	* **Whether/how to cover mixed numerology case**
		+ **Alt.1: Support the mixed numerology case (as TP in R1-2004259)**
		+ **Alt.2: Not support the mixed numerology case in Rel-16**
3. **Remaining issue for aperiodic CSI-RS triggering with beam switching timing of 224 and 336**
	* **Whether/how to capture the new capability signaling for aperiodic CSI-RS triggering with beam switching timing of 224 and 336 in TS38.214**
		+ **TP in R1-2003763 as starting point for the discussion**

Companies are encouraged to check above FL proposals and to provide feedback if any in below.

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# **Remaining issue for CLI measurement**

In [2], the following remaining issue regarding CLI measurement is identified.

* The RAN1#100bis-e agreement “A multi-port SRS-RSRP measurement is not supported in Rel-16” should be captured in 38.214.

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| In the RAN1 #100bis e-meeting, the agreements reached in the topic of UE features for CLI/RIM are as follows.Agreements:* FG17-1 is kept for support of CLI-RSSI measurement.

...* FG17-2 is kept for support of SRS-RSRP measurement.
* FG17-2 includes component “maximum number of measurement resources configured for SRS-RSRP measurement” and “maximum number of measurement resources configured for SRS-RSRP measurement within a slot”.
* Candidate values for FG17-2 component “maximum number of measurement resources configured for SRS-RSRP measurement” are {4, 8, 16, 32}.
* Candidate values for FG17-2 component “maximum number of measurement resources configured for SRS-RSRP measurement within a slot” are {2, 4, 8}.
* FG-17-2 is reported per UE with FR1/FR2 differentiation.
* A joint limit for CLI SRS, SSB and CSI-RS for RSRP measurement in a slot is not defined in Rel-16.
* A multi-port SRS-RSRP measurement is not supported in Rel-16.

Wherein, the agreements of two new components and the corresponding candidate values in FG17-2 for SRS-RSRP measurement belong to UE feature, which do not need to be reflected in physical layer specifications. However, in our opinion, the agreement of “A multi-port SRS-RSRP measurement is not supported in Rel-16” should be captured in 38.214.The following TP in TS 38.214 are proposed to capture above agreement on ports of SRS resource.**Proposal 1: Adopt the following text proposal.**------------------------------- < Start of text proposal for Clause 5.1.6.4 of 38.214> ------------------------------------5.1.6.4 SRS reception procedure for CLIThe SRS resources defined in Clause 6.4.1.4 of [4, TS 38.211] may be configured for SRS-RSRP measurement for CLI, as defined in Clause 5.1.19 of [7, TS 38.215]. The UE is not expected to measure SRS-RSRP with a subcarrier spacing other than the one configured for the active BWP confining the SRS resource. The UE is not expected to measure SRS-RSRP using the SRS-RSRP measurement resource which is not fully confined within BW of DL active BWP. The UE is not expected to measure more than 32 SRS resources, and the UE is not expected to receive more than 8 SRS resources in a slot. The UE is not expected the number of antenna ports per SRS resource for SRS-RSRP measurement is larger than one. -------------------------------------------------- < End of text proposal> ----------------------------------------------------- |

Based on above, following remaining issue for CLI measurement and reporting should be discussed in RAN1#101-e meeting.

* **Whether/how to capture the agreement regarding the number of antenna ports per SRS resource for SRS-RSRP measurement in TS38.214**
	+ **TP in R1-2003492 as starting point for the discussion**

# **Remaining issue for aperiodic CSI-RS triggering with beam switching timing of 224 and 336**

In [5], the following remaining issue regarding aperiodic CSI-RS triggering with beam switching timing of 224 and 336 is identified.

* Since UE is not aware which functionality is supported by the gNB, new Rel-16 UE capability signaling for indicating beam switching timing of 224 and 336 should be introduced while Rel-15 capability and UE behavior should be unchanged. If the UE indicates *beamSwitchTiming* value other than 48, there would be an ambiguity on the actually assumed threshold for aperiodic CSI-RS.

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| Based on the agreement TP was agreed to TS 38.214 [2] and LS was sent to RAN2 [3]. The text in CR and LS to RAN2, however, assumes the Rel-15 UE capability will be used to indicate the values of 224 and 336. It should be noted that in the UE is not aware which functionality is supported by the gNB. Due to such uncertainty UE is unlikely to report 224 or 336 values using Rel-15 capability to ensure backward compatibility for the “old” gNB potentially not supporting UE behaviour for beam switching timing of 224 and 336. Then, the agreed enhancement for aperiodic CSI-RS based on Rel-15 capability indication becomes useless. **Observation**: * *Rel-15 capability signalling is not suitable for indication of the beam switching timing of 224 and 336.*

In order to solve the problem, it is necessarily to introduce Rel-16 capability for (e.g., beamSwitchTiming-r16) indicating new values of {224, 336} while keep supporting Rel-15 capability for the backward compatibility purpose without any changes. New UE behaviour in TS 38.214 defining threshold of 48 symbols for aperiodic CSI-RS can be enabled depending whether UE includes Rel-16 capability or not. It should be also noted that Rel-16 enhancement with beam switching timing of {224, 336} is supported based on UE capability and without explicit RRC configuration from gNB. Such approach was not recommended by RAN2 in the LS [4]. As the result ambiguity may occur on the actually assumed threshold for aperiodic CSI-RS, if UE in Rel-15 indicates *beamSwitchTiming* value other than 48 and also include new *beamSwitchTiming*-*r16* in Rel-16 implying threshold of 48 according to TS 38.214. To avoid ambiguity on the actually assumed threshold for aperiodic CSI-RS without explicit RRC signalling, UE including Rel-16 capability of {224, 336} should be required to include the value of 48 using Rel-15 *beamSwitchTiming*. The TPs capturing the above proposals to TS 38.214 and TS 38.306 are provided below:

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| 5.2.1.5.1 Aperiodic CSI Reporting/Aperiodic CSI-RS when the triggering PDCCH and the CSI-RS have the same numerology…If the scheduling offset between the last symbol of the PDCCH carrying the triggering DCI and the first symbol of the aperiodic CSI-RS resources in a *NZP-CSI-RS-ResourceSet* configured without higher layer parameter *trs-Info* is smaller than the UE reported threshold *beamSwitchTiming,* as defined in [13, TS 38.306], when the reported value is one of the values of {14, 28, 48}, or is smaller than 48 when the reported value of *beamSwitchTiming-r16* is one of the values of {224, 336}.- if there is any other DL signal with an indicated TCI state in the same symbols as the CSI-RS, the UE applies the QCL assumption of the other DL signal also when receiving the aperiodic CSI-RS. The other DL signal refers to PDSCH scheduled with offset larger than or equal to the threshold *timeDurationForQCL,* as defined in [13, TS 38.306], aperiodic CSI-RS scheduled with offset larger than or equal to the UE reported threshold *beamSwitchTiming* when the reported value is one of the values {14,28,48}, aperiodic CSI-RS scheduled with offset larger than or equal to 48 when the reported value of *beamSwitchTiming-r16* is one of the values {224, 336}, periodic CSI-RS, semi-persistent CSI-RS;- else, when receiving the aperiodic CSI-RS, the UE applies the QCL assumption used for the CORESET associated with a monitored search space with the lowest *controlResourceSetId* in the latest slot in which one or more CORESETs within the active BWP of the serving cell are monitored.- If the scheduling offset between the last symbol of the PDCCH carrying the triggering DCI and the first symbol of the aperiodic CSI-RS resources is equal to or greater than the UE reported threshold *beamSwitchTiming* when the reported value is one of the values of {14,28,48}, or is equal to or greater than 48 when the reported value of *beamSwitchTiming-r16* is one of the values of {224, 336}, the UE is expected to apply the QCL assumptions in the indicated TCI states for the aperiodic CSI-RS resources in the CSI triggering state indicated by the CSI trigger field in DCI. |

| ***beamSwitchTiming-16***beamSwitchTiming-16 of value (sym224 or sym336) indicates the minimum number of required OFDM symbols between the DCI triggering aperiodic CSI-RS and the corresponding aperiodic CSI-RS transmission in a CSI-RS resource set configured with repetition ‘ON’. UE indicating *beamSwitchTiming-16* and *beamSwitchTiming* for the same band shall set *beamSwitchTiming* to 48*.* | Band | No | No | FR2 only |
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Based on above, following remaining issue for aperiodic CSI-RS triggering with beam switching timing of 224 and 336 should be discussed in RAN1#101-e meeting. It should be noted that the introduction of the new capability signaling is to be discussed in AI 7.2.11.12. Therefore, one possible way to handle this issue is to start the discussion on TP after the introduction of the new capability signaling is agreed in AI 7.2.11.12.

* **Whether/how to capture the new capability signaling for aperiodic CSI-RS triggering with beam switching timing of 224 and 336 in TS38.214**
	+ **TP in R1-2003763 as starting point for the discussion**

# **Remaining issue for half duplex operation in CA**

In [1], the following remaining issues regarding half duplex operation in CA are identified.

* If UE is configured with multiple serving cells and at least one of the serving cells is deactivated, it is not clear whether this deactivated SCell is included for DL/UL confliction determination among the configured serving cells. To avoid unnecessary dropping, all symbols on deactivated SCell can be considered as semi-static flexible symbol for confliction determination on configured serving cells.
* Similar situation occurs for dormant SCells, and hence a solution to avoid unnecessary dropping on other serving cells is necessary when dormant SCell is determined as a reference serving cell.

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| As captured in [1][2], when UE is configured with different DL/UL direction simultaneously on multiple configured serving cells, UE need to handle the collision by dropping DL reception or UL transmission. However, it is not clear whether the deactivated scell is also considered for DL/UL confilction determination. According to current specification, for a deactivated Scell, if a symbol is SFI D/U or RRC D/U according to RRC configuration, this deactivated Scell can also be determined as reference cell, and the transmission or reception on other serving cells may be dropped due to “collision” with the deactivated Scell, even if there is no actual Tx/Rx operation on the deactivated Scell.**Observation 1: If UE is configured with multiple serving cells and at least one of the serving cells is deactivated, it is not clear whether this deactivated scell is included for DL/UL confiction determination among the configured serving cells.**Since the DL reception and UL transmission is suspended on a deactivated scell according to TS38.321, there would be no confliction between an activated cell and deactivated scell, deactivated scell would not be considered in serving cells for DL/UL confliction determination. In this case, unnecessary dropping on other serving cells can be avoided. **Proposal 1: Clafify that RRC configured DL reception and UL transmission, for a deactivated Scell, would not be considered for confliction determination on configured serving cells.**According to [1][2], semi static DL and UL symbols for a scell, are also considered for confliction determination among configured serving cells. For deactivated scells, *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* can also be provided, which means transmission or reception on other serving cells may also be dropped due to semi static DL or UL configuration on deactivated Scell.Furthermore, if a symbol is configured with semi-static flexible, and there is no RRC configured DL/UL transmissions in this symbol, this serving cell will not be the reference cell on this symbol. Thus, transmission or reception on this symbol of other serving cells would not be affected by this serving cell. Therefore, if a Scell is deactivated, all the symbols on this serving cell can be considered as flexible symbol, instead of SFI D/U. In this case, DL/UL transmission dropping on other serving cells due to “collision” with a deactivated Scell can be avoided**Proposal 2: For a deactivated Scell, UE assumes all the symbols on deactivated Scell as semi-static flexible symbol for confliction determination on configured serving cells.*** **Capture the TP in R1-2003423.**

Similar situation occurs for dormant Scells, in which RRC configured and dynamic scheduled UL/DL transmissions are stopped, except for CSI-RS for BFD, CSI-RS for P/SP-CSI reporting and for P-SRS with long periodicity (FFS for P-SRS) [3][4]. However, it is not clear whether the confliction handling among the serving cells is performed based on the RRC configured transmission/reception or actual UE behavior considering the restrictions on the dormant Scells in current specification. Besides, since the dynamic transmission on dormant Scells are stopped, it seems not necessary to cancel RRC D/U on other cells if symbol on dormant Scell, which is determined as reference cell, is configured as SFI U/D. In other words, if the confliction handling is performed based on RRC configuration without considering the suspended transmission/reception on dormant Scell, the transmission or reception on other serving cells may be dropped unnecessarily.**Proposal 3: Solutions are needed to avoid unnecessary transmission/reception dropping on other serving cells when dormant Scell is determined as the reference serving cell.**Appendix : Text proposals for Half Duplex Operation in CA**11.1 Slot configuration****< Unchanged text is omitted >**If a UE- is configured with multiple serving cells and is provided *half-duplex-behavior-r16* = 'enable', and- is not capable of simultaneous transmission and reception on any of the multiple serving cells, and- indicates support of capability for half-duplex operation in CA with unpaired spectrum, and - is not configured to monitor PDCCH for detection of DCI format 2-0 on any of the multiple serving cells, the UE determines a reference cell for a symbol as a cell with the smallest cell index among serving cells where the symbol is configured as- downlink, or uplink as indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*- uplink, if the symbol is flexible and the UE is configured to transmit SRS, PUCCH, PUSCH, or PRACH on the symbol- downlink, if the symbol is flexible and the UE is configured to receive PDCCH, PDSCH or CSI-RS on theUE assumes the symbols on deactivated Scell as flexible for reference cell determination, regardless of *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated.***< Unchanged text is omitted >** |

In [3], the following remaining issue regarding half duplex operation in CA are identified.

* When transmission directions of multiple other cells are not aligned in case 3 or 16, UE cannot determine to follow the transmission direction of which cell. If reference cell is semi SFI D or RRC D, UE should drop high layer configured D on other cells if there is dynamic U on one of the other cells.

However, according to following conclusion made at the RAN1#100bis-e meeting, this issue does not need to be discussed.

***Conclusion:***

*The reference cell is determined with excluding the effects of UL TA and DL and UL timing differences.
The existence of directional conflict between cells is determined with including the effects of UL TA and DL and UL timing differences.
The error cases resulting from the discrepancy between the methods of reference cell determination and duplex direction conflict determination will not be discussed further in Rel-16. These cases include at least:
    - duplex direction conflict between cells where both cells are reference
    - duplex direction conflict between cells where there is no reference
    - conflict between Dynamic D and Dynamic U*

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| According to the agreement for half-duplex UE operation, UE does not always follow reference cell transmission direction. For example, in case 3 and case 16 as shown in Table 1, UE will drop the transmission on reference cell for inter-band CA, the issue is when transmission directions of multiple other cells are not aligned, UE cannot determine to follow the transmission direction of which cell. Table 1 Half-duplex UE behavior in different cases

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| **No** | **Ref cell** | **Other cell** | **UE behavior** | **Note** |
| 3 | Semi SFI D | Dynamic U | Alt 1: Allowed to drop D for inter-bandError case in intra-band | Overriding semi SFI D to F on reference cell for the UE |
| 16 | RRC D | Dynamic U | Alt 1: Allowed to drop D for inter-bandError case in intra-band |  |

As an example shown in Table 2, if UE is configured with three cells, Pcell is configured with semi SFI D or RRC D, a dynamic U is scheduled on Scell 1 and RRC D is configured on Scell2. Then, according to the agreement, Pcell is the reference cell, UE should drop D on reference cell and transmit dynamic U on Scell1, but there is no conflict between Pcell and Scell2, it is not clear whether a half-duplex UE should drop dynamic U on Scell 1 or drop RRC D on Scell 2. From our perspective, UE should prioritize dynamic U on Scell1 in this case according to the principle of case 3 and case 16.Table 2 Conflict direction on Scells

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| **Pcell (Reference cell)** | **Scell1** | **Scell2** | **UE behavior** |
| Semi SFI D | Dynamic U | RRC D | drop D or drop U? |
| RRC D | Dynamic U | RRC D | drop D or drop U? |

***Proposal 1: For a half-duplex CA UE, if reference cell is semi SFI D or RRC D, UE should drop high layer configured D on other cells if there is dynamic U on one of the other cells.***In addition, the agreements for inter-band CA case are not correctly captured in the specification. Hence, a text proposal is provided below for half-duplex operation in CA in 38.213 section 11.1.-------------------------------------------------- Start of text proposal ------------------------------------------------------If the reference cell and another cell for a UE operate in different frequency bands and if the UE - is configured with multiple serving cells and is provided *half-duplex-behavior-r16* = 'enable', - is not capable of simultaneous transmission and reception on any of the multiple serving cells, - indicates support of capability for half-duplex operation in CA with unpaired spectrum, and - is not configured to monitor PDCCH for detection of DCI format 2-0, the UE - UE assumes symbol on the other cell as flexible, is not required to receive higher layer configured PDCCH, PDSCH, or CSI-RS and not expected to transmit higher layers configured SRS, PUCCH, PUSCH, or PRACH, when *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* indicates symbol as downlink or uplink on the other cell and as uplink or downlink for the reference cell, respectively, - transmits a signal/channel on a symbol of the other cell and is not required to receive a higher layer configured PDCCH, PDSCH, or CSI-RS on the symbol on the reference cell and any of the other cells when the symbol is indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigDedicated* for the reference cell and if the UE detects a DCI format scheduling the transmission on the symbol on the other cell,- transmits a signal/channel on a symbol of the other cell and is not required to receive a higher layer configured PDCCH, PDSCH, or CSI-RS on the symbol on the reference cell and any of the other cells, if the symbol on the reference cell is flexible and the UE is configured by higher layers to receive PDCCH, PDSCH, or CSI-RS on the symbol on the reference cell and the UE detects a DCI format scheduling the transmission on the symbol on the other cell. ----------------------------------------------------- End of text proposal ------------------------------------------------------ |

In [7], the following remaining issues regarding half duplex operation in CA are identified.

* If UE is configured with multiple serving cells and at least one of the serving cells is deactivated, it is not clear whether this deactivated SCell can be reference cell. To simplify already quite complicated feature, it is proposed to determine reference cells among configured cells.
* The support of the mixed numerology case remains open. It is proposed to support the case by defining the reference cell as cell with lowest SCS among cells for which the symbols (configured as RRC D/U or semi SFI D/U) are overlapping.

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| The issue of deactivated Scell. The question is whether deactivated Scell can be reference cell. Obviously if Scell is deactivated, direcitonal conflict cannot happen. On the other hand, it was assumed that reference cell is determined based on configuration, and Scell-activation/deactivation would result in change of reference cell dynamically based on MAC-CE command. To simplify already quite complicated feature, we propose to determine reference cells among configured cells. **Proposal 1**: *Adopt the below TP for TS38.213 to clarify that reference cell is determined based on configured set of serving cells.*

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| 11 UE-group common signalling If the UE is configured with a SCG, the UE shall apply the procedures described in this clause for both MCG and SCG- When the procedures are applied for MCG, the terms 'secondary cell', 'secondary cells', 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell, serving cells belonging to the MCG respectively.- When the procedures are applied for SCG, the terms 'secondary cell', 'secondary cells', 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells (not including PSCell), serving cell, serving cells belonging to the SCG respectively. The term 'primary cell' in this clause refers to the PSCell of the SCG.11.1 Slot configuration<unchanged text omitted >If a UE- is configured with multiple serving cells and is provided *half-duplex-behavior-r16* = 'enable', and- is not capable of simultaneous transmission and reception on any of the multiple serving cells, and- indicates support of capability for half-duplex operation in CA with unpaired spectrum, and - is not configured to monitor PDCCH for detection of DCI format 2-0 on any of the multiple serving cells, the UE determines a reference cell for a symbol as a configured cell with the smallest cell index among serving cells where the symbol is configured as- downlink, or uplink as indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*- uplink, if the symbol is flexible and the UE is configured to transmit SRS, PUCCH, PUSCH, or PRACH on the symbol-downlink, if the symbol is flexible and the UE is configured to receive PDCCH, PDSCH or CSI-RS on the symbol.<unchanged text omitted > |

~The mixed numerology case (which remained open after RAN1#100e) can be handled by defining the reference cell as cell with lowest SCS among cells for which the symbols (configured as RRC D/U or semi SFI D/U) are overlapping.**Proposal 2:** *Consider to support mixed numerology scenario for half-duplex feature, consider adopting the following TP for TS 38.213.*

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| 11 UE-group common signalling If the UE is configured with a SCG, the UE shall apply the procedures described in this clause for both MCG and SCG- When the procedures are applied for MCG, the terms 'secondary cell', 'secondary cells', 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell, serving cells belonging to the MCG respectively.- When the procedures are applied for SCG, the terms 'secondary cell', 'secondary cells', 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells (not including PSCell), serving cell, serving cells belonging to the SCG respectively. The term 'primary cell' in this clause refers to the PSCell of the SCG.11.1 Slot configuration<unchanged text omitted >If a UE- is configured with multiple serving cells and is provided *half-duplex-behavior-r16* = 'enable', and- is not capable of simultaneous transmission and reception on any of the multiple serving cells, and- indicates support of capability for half-duplex operation in CA with unpaired spectrum, and - is not configured to monitor PDCCH for detection of DCI format 2-0 on any of the multiple serving cells, the UE determines a reference cell for a symbol of the lowest sub-carrier spacing as a cell with the smallest sub-carrier spacing first and with the smallest cell index among serving cells second where the symbol or at least one of overlapping symbols is configured as- downlink, or uplink as indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*- uplink, if the symbol is flexible and the UE is configured to transmit SRS, PUCCH, PUSCH, or PRACH on the symbol-downlink, if the symbol is flexible and the UE is configured to receive PDCCH, PDSCH or CSI-RS on the symbol.<unchanged text omitted > |

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Based on above, following remaining issues for half-duplex operation in CA should be discussed in RAN1#101-e meeting.

* **Whether/how to clarify the reference cell determination and confliction determination for deactivated SCell**
	+ **Alt.1: Clarify that the reference cell is determined based on configured set of serving cells (as TP in R1-2004259)**
	+ **Alt.2: Clarify that RRC configured DL reception and UL transmission, for a deactivated Scell are not considered for confliction determination on configured serving cells, and UE assumes all the symbols on deactivated Scell as semi-static flexible symbol for confliction determination on configured serving cells (as TP in R1-2003423)**
* **Whether/how to cover mixed numerology case**
	+ **Alt.1: Support the mixed numerology case (as TP in R1-2004259)**
	+ **Alt.2: Not support the mixed numerology case in Rel-16**

# **Issue for TRS muting**

In [4], the following issue regarding TRS muting is identified.

* An operator may not deploy R16 NR with reduced BW (7MHz) since there is no 7MHz channel bandwidth defined in RAN4 specifications and companies don’t have the consensus to support BWP size other than CORESET0 size and the size corresponding to all RAN4-specified UE channel bandwidths for a given SCS in Rel-15. Four options are proposed to solve the issue.

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| In RAN1#100-e, R1-2001121 proposed TRS muting to address the issue when NR coexists with a narrow band system as shown in the following figure.Figure 1. TRS issue when NR coexists with a narrow band system (*Source: R1-2001121*)Based on our understanding, the fundamental issue comes from two folds.* There is no 7MHz channel bandwidth defined in RAN4 specifications
* Companies doesn’t have the consensus to support BWP size other than CORESET0 size and the size corresponding to all RAN4-specified UE channel bandwidths for a given SCS in Rel-15

As pointed in a RAN1 LS to RAN2/4 (R1-1909900), RAN1 specifications have the flexibility to support any BWP size from 1 PRB to 275 PRBs, although currently Rel-15 does not support BWP sizes smaller than the RBG size or the PRG size. Therefore, we don’t see any problem in RAN1 specifications to support the deployment shown in Figure 1. Though there is one note in FG6-1 “Basic BWP operation with restriction” in TR38.822, saying “this feature should be mandatory without capability signalling for at least BWPs which is the same as the set of specified channel BW”, there is no UE capability specified in TS38.306 & TS38.331 for the support of BWP sizes different from the set of specified channel BW, it implicitly means that all BWP sizes are mandatory for a UE to support in Rel-15. However, we understand the reality that not all UE vendors implement all BWP sizes in their Rel-15 products. Therefore, we proposed the following options for companies to discuss to resolve the issue.* Option #1 (top preference): Clarify in RAN1 that all BWP sizes are mandatory for all UEs in FG6-1 for Rel-15
	+ LS to RAN2 (cc RAN4) to update the note in FG6-1 in TR38.822 as “*This feature should be mandatory without capability signaling for ~~at least~~all BWPs from 1 to 275 PRBs ~~which is the same as the set of specified channel BW~~.~~RAN4 may discuss other BW requirements~~. No RF requirements are required for the BWP sizes.*”
* Option #2 (second preference): Clarify in RAN1 that FG6-1 doesn’t have any restriction on BWP size but which BWP sizes are mandatory for all UEs is specified in RAN4 in a release-independent manner
	+ LS to RAN2 to update the note in FG6-1 in TR38.822 as “*This feature doesn’t put any restriction on ~~should be mandatory without capability signaling for at least~~ BWP size ~~which is the same as the set of specified channel BW~~.~~RAN4 may discuss other BW requirements~~but which BWP sizes are mandatory for all UEs is specified in RAN4 in a release-independent manner. No RF requirements are required for the BWP sizes.*”
	+ LS to RAN4 for the specification
* Option #3 (second preference): Introduce two new UE capabilities for non-nominal BWP sizes in Rel-16
	+ Introduce optional per band Rel-16 capability 14-x, which indicates the support of [32] PRB BWP size in addition to the BWP sizes that match the channel BW cases defined in Rel-15
	+ Introduce optional per band Rel-16 capability 14-y, which indicates the support of all other BWP sizes in addition to [32] PRB BWP size and the BWP sizes that match the channel BW cases defined in Rel-15
	+ For the above new FGs, no further RF requirement is added compared with Rel-15
	+ Send LS to RAN4/5 on the above new FGs and RAN4/5 to decide whether a demodulation test case is needed for the supported BWP size or not for Rel-16 UEs.
* Option #4 (acceptable): For Rel-16, TRS bandwidth is given by the higher layer parameter *freqBand* configured by *CSI-RS-ResourceMapping* when a UE is configured with a carrier bandwidth ≤ 10MHz using 15KHz SCS
	+ UE reports via capability signalling whether it supports or not

Our top preference is Option #1 because it’s a more clean & natural way to support the deployment in Figure 1. Option #2 & #3 are our second preference if companies still don’t have consensus on Option #1. Option #4 is the least preferred option but also acceptable. However, unlike other options, Option #4 requires all UE vendors to change their implementations. Note that above options don’t fully resolve the issues for the deployment in Figure 1. Due to the lack of UE RF requirements for 7MHz, network has to guarantee there is no excessive out of band emission between two neighbouring systems; otherwise, it doesn’t work.**Proposal #1: Adopt one of the following options.*** **Option #1: Clarify in RAN1 that all BWP sizes are mandatory for all UEs in FG6-1 for Rel-15**
* **Option #2: Clarify in RAN1 that FG6-1 doesn’t have any restriction on BWP size but which BWP sizes are mandatory for all UEs is specified in RAN4 in a release-independent manner**
* **Option #3: Introduce two new UE capabilities for non-nominal BWP sizes in Rel-16**
* **Option #4: For Rel-16, TRS bandwidth is given by the higher layer parameter *freqBand* configured by *CSI-RS-ResourceMapping* when a UE is configured with a carrier bandwidth ≤ 10MHz using 15KHz SCS**
	+ **UE reports via capability signalling whether it supports or not**

**Proposal #2: If Option #4 is adopted, adopt the following TP for TS38.214.****-----------------Begin of Text Proposal-------------------------------**5.1.6.1.1 CSI-RS for trackingA UE in RRC connected mode is expected to receive the higher layer UE specific configuration of a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info*.For a *NZP-CSI-RS-ResourceSet* configured with the higher layer parameter *trs-Info*, the UE shall assume the antenna port with the same port index of the configured NZP CSI-RS resources in the *NZP-CSI-RS-ResourceSet* is the same. - For frequency range 1, the UE may be configured with one or more NZP CSI-RS set(s), where a *NZP-CSI-RS-ResourceSet* consists of four periodic NZP CSI-RS resources in two consecutive slots with two periodic NZP CSI-RS resources in each slot. If no two consecutive slots are indicated as downlink slots by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigDedicated*, then the UE may be configured with one or more NZP CSI-RS set(s), where a *NZP-CSI-RS-ResourceSet* consists of two periodic NZP CSI-RS resources in one slot. - For frequency range 2 the UE may be configured with one or more NZP CSI-RS set(s), where a *NZP-CSI-RS-ResourceSet* consists of two periodic CSI-RS resources in one slot or with a *NZP-CSI-RS-ResourceSet* of four periodic NZP CSI-RS resources in two consecutive slots with two periodic NZP CSI-RS resources in each slot. A UE configured with *NZP-CSI-RS-ResourceSet(s)* configured with higher layer parameter *trs-Info* may have the CSI-RS resources configured as:- Periodic, with the CSI-RS resources in the *NZP-CSI-RS-ResourceSet* configured with same periodicity, bandwidth and subcarrier location- Periodic CSI-RS resource in one set and aperiodic CSI-RS resources in a second set, with the aperiodic CSI-RS and periodic CSI-RS resource having the same bandwidth (with same RB location)and the aperiodic CSI-RS being 'QCL-Type-A' and 'QCL-TypeD', where applicable, with the periodic CSI-RS resources. For frequency range 2, the UE does not expect that the scheduling offset between the last symbol of the PDCCH carrying the triggering DCI and the first symbol of the aperiodic CSI-RS resources is smaller than the UE reported *ThresholdSched-Offset*. The UE shall expect that the periodic CSI-RS resource set and aperiodic CSI-RS resource set are configured with the same number of CSI-RS resources and with the same number of CSI-RS resources in a slot. For the aperiodic CSI-RS resource set if triggered, and if the associated periodic CSI-RS resource set is configured with four periodic CSI-RS resources with two consecutive slots with two periodic CSI-RS resources in each slot, the higher layer parameter *aperiodicTriggeringOffset* indicates the triggering offset for the first slot for the first two CSI-RS resources in the set.A UE does not expect to be configured with a *CSI-ReportConfig* that is linked to a *CSI-ResourceConfig* containing an *NZP-CSI-RS-ResourceSet* configured with *trs-Info* and with the *CSI-ReportConfig* configured with the higher layer parameter *timeRestrictionForChannelMeasurements* set to 'configured'.A UE does not expect to be configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to other than 'none' for aperiodic NZP CSI-RS resource set configured with *trs-Info.*A UE does not expect to be configured with a *CSI-ReportConfig* for periodic NZP CSI-RS resource set configured with *trs-Info*.A UE does not expect to be configured with a *NZP-CSI-RS-ResourceSet* configured both with *trs-Info* and *repetition*.Each CSI-RS resource, defined in Subclause 7.4.1.5.3 of [4, TS 38.211], is configured by the higher layer parameter *NZP-CSI-RS-Resource* with the following restrictions:- the time-domain locations of the two CSI-RS resources in a slot, or of the four CSI-RS resources in two consecutive slots (which are the same across two consecutive slots), as defined by higher layer parameter *CSI-RS-resourceMapping*, is given by one of- , , or for frequency range 1 and frequency range 2,- , , , , ,  or  for frequency range 2.- a single port CSI-RS resource with density  given by Table 7.4.1.5.3-1 from [4, TS 38.211] and higher layer parameter *density* configured by *CSI-RS-ResourceMapping.* - if carrier and the bandwidth of the CSI-RS resource is given by the higher layer parameter *freqBand* configured by *CSI-RS-ResourceMapping*, otherwise, the bandwidth of the CSI-RS resource, as given by the higher layer parameter *freqBand* configured by *CSI-RS-ResourceMapping*, is the minimum of 52 and resource blocks, or is equal to resource blocks. For operation with shared spectrum channel access, *freqBand* configured by *CSI-RS-ResourceMapping*, is the minimum of 48 and resource blocks, or is equal to resource blocks.- the UE is not expected to be configured with the periodicity of  slots if the bandwidth of CSI-RS resource is larger than 52 resource blocks.- the periodicity and slot offset for periodic NZP CSI-RS resources, as given by the higher layer parameter *periodicityAndOffset* configured b*y NZP-CSI-RS-Resource*, is one of slots where 10, 20, 40, or 80 and where µ is defined in Subclause 4.3 of [4, TS 38.211]. - same *powerControlOffset* and *powerControlOffsetSS* given by*NZP-CSI-RS-Resource* value across all resources.<Omitted>**-----------------End of Text Proposal-------------------------------** |

At the last RAN1 meeting, there was no consensus on solution to solve the issue even after extensive discussion.

Based on above, the issue for TRS muting should be discussed in RAN1#101-e meeting only if some offline consensus has already been achieved. Otherwise RAN1 would just repeat same discussion/situation as in the last meeting.

# **Issue for conditions of rate matching pattern overlapping with PDSCH DMRS symbols**

In [8], the following issues for conditions of rate matching pattern overlapping with PDSCH DMRS symbols are identified.

* Whether or not a SSB should be always covered by additional rate-matching pattern whose symbol length is longer than the length of all possible scheduled symbols
* Whether or not the configured rate-matching pattern should always cover all possible scheduled symbols
* Whether PDSCH DMRS can be “rate-matched” out in case of wideband PRG or not
* Whether fractional PRG is allowed or not
* Whether to increase the maximum number of rate matching patterns configurable to a UE or not

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| Regarding the conditions of “collision between PDSCH DMRS REs and REs not available for PDSCH”, the following questions should be answered.**Q1: Whether or not a SSB should be always covered by additional rate-matching pattern whose symbol length is longer than the length of all possible scheduled symbols*** **Option 1.1: Yes.** An additional RM pattern (in orange as shown in Figure 1 below) must be always configured to fully cover the SSB resources (in red). Since the semi-static RM pattern has to cover all possible symbols dynamically scheduled by a DCI, it has a fixed symbol length as 12 symbols or more.
* **Option 1.2: No.** There is no additional RM pattern configured to cover SSB resources but UE behavior is specified. Once any DM-RS RE of a PRB indicated by DCI collides with SSB, the UE assumes that the entire PRB is not available in all scheduled symbols for both PDSCH and DM-RS, i.e. the effective rate-matched resource is the entire PRB. (in black as shown in Figure 1 below)

 **Opt. 1.1 Opt. 1.2****Figure 1 Illustrations of Opt. 1.1 (Left) and Opt. 1.2 (Right) for PDSCH slot scheduling**Comparing Option 1.1 and Option 1.2, the latter option is absolutely better than the former one.~~***Proposal 1****: A UE shall assume that a PRB indicated by the frequency domain resource assignment field in a DCI for PDSCH is not available for both PDSCH and DM-RS in all the symbols scheduled by the DCI if any PDSCH DM-RS RE in the PRB in any scheduled symbol overlaps with any REs corresponding to SSB.***Q2: Whether or not the configured rate-matching pattern should always cover all possible scheduled symbols*** **Option 2.1: Yes.** Any RM pattern (in orange as shown in **Figure 3** below) must be semi-statically configured in slot granularity, i.e. fully cover all OF symbols in a slot (in orange as shown in ) unless it does not overlap with any potential DMRS symbols.
* **Option 2.2: No.** It is symbol level that the time-domain granularity for a RM pattern overlapping with potential DMRS symbols. A UE behavior is specified similar to the SSB case Option 1.2. Once any DM-RS RE of a PRB indicated by DCI collides with a RM pattern, the UE assumes that the entire PRB is not available in all scheduled symbols for both PDSCH and DM-RS, i.e. the effective rate-matched resource is the entire PRB. (in black as shown in **Figure 3** below)

**Opt. 2.1 Opt. 2.2****Figure 3 Illustrations of Opt. 2.1 (Left) and Opt. 2.2 (Right) for PDSCH slot scheduling**Obviously, Option 2.2 is better than Option 2.1 in terms of spectrum efficiency (SE) and scheduling flexibility.~***Proposal 2****: A UE shall assume that a PRB indicated by the frequency domain resource assignment field in a DCI for PDSCH is not available for both PDSCH and DM-RS in all the symbols scheduled by the DCI if all PDSCH and DM-RS REs in the PRB in all scheduled symbol overlap with any rate-matching patterns, i.e. Opt. 2.1 is supported with specified UE behavior.***Q3: Whether PDSCH DMRS can be “rate-matched” out in case of wideband PRG or not** * **Option 3.1: Yes.**
* **Option 3.2: No.**

Opt 3.2 is preferred, because of the following text in TS 38.214. It implies that UE needs contiguous DMRS PRBs for channel estimation in case of “wideband” PRG.

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| If  is determined as "wideband", the UE is not expected to be scheduled with non-contiguous PRBs and the UE may assume that the same precoding is applied to the allocated resource. |

***Proposal 3****: Only PRG size 2 and 4 are addressed for allowing PDSCH DMRS (within the resources indicated by a DCI) not available due to SSB and rate-matching patterns.***Q4: Whether fractional PRG is allowed or not*** **Option 4.1:** Fractional PRG is not allowed.
* **Option 4.2:** Fractional PRGs are allowed but with limited number, e.g., 4.

~Comparing the two options, Option 4.2 is preferred since Option 4.1 has the following disadvantages.* It cannot support Option 1.2 to solve the popular issue of SSB. And it prevents gNBs from supporting forward compatibility and LTE-NR coexistence.
* On the contrary, Option 4.2 solves all important issues above. With limited number of fractional PRG, the UE complexity improvement and performance degradation will be negligible.
* Rel-15 UEs are mandatory to support fractional PRGs because they have supported the following, which should be inherited by Rel-16 UEs,
	+ Downlink resource allocation type 1, in which both the indicated starting PRB and ending PRB are allowed to be not aligned with PRG boundary.
	+ Active BWP boundary is allowed to be not aligned with PRG boundary.

~On top of **Figure 5**, more than 4 fractional PRGs may be required for the following cases.* Multiple SSBs are configured in FDM manner for the coverage of skycrapers.
* The eMTC/NB-IoT is configured within the bandwidth.
* LTE PSS/SSS/PBCH is configured within the NR bandwidth for LTE-NR DL sharing.
* PDSCH for eMBB UEs may be rate-matched around search space/CORESET configured for URLLC UEs which are spanning at different OF symbols in a slot as the UE feature 3-5b.

Thus, it is preferred for UE to support 6 fractional PRGs. ***Proposal 4****: For PDSCH rate-matching purpose, fractional PRGs are allowed but with limited number. The minimum number of fractional PRGs that UEs support for rate-matching with SSB and rate-matching patterns is [4 or 6].** *A fractional PRG contains at least one PRB where PDSCH DMRS REs overlap with any REs corresponding to SSB or rate matching patterns.*

**Q5: Whether to increase the maximum number of rate matching patterns configurable to a UE or not**For the collision issue between DMRS and RM pattern, the only spec impact in TEI-16 is to specify UE behavior to handle the case, which is not related to the number of configured rate matching patterns. To minimize UE complexity, the maximum number of rate matching patterns configurable to a UE should NOT be increased, and it should be kept the same as that in Rel-15. ***Proposal 5****: The maximum number of rate matching patterns configurable to a UE, including both the original RB-symbol level rate-matching patterns and the rate-matching patterns that may overlap with DMRS, is the same as Rel-15.*~If it is preferred to conclude the scope of Rel-16 TEI on PDSCH rate-matching around SSB and rate-matching patterns before jumping into any discussion of technical details, then the following proposal is given based on above analysis,***Proposal 6****: The objectives for Rel-16 TEI on PDSCH rate-matching around SSB and rate-matching patterns are the following,** *Specify UE behavior for rate-matching around SSB as Opt. 1.2*
* *Specify rate-matching according to rate-matching pattern which can overlap with scheduled PDSCH DMRS, as Opt 2.1*
	+ *For the rate-matching pattern which may overlap with DMRS,*
		- *It is semi-statically acknowledged by a UE that the rate-matching pattern is probably overlapping with PDSCH DMRS*
			* *For a rate-matching pattern with no such acknowledgement, the UE behavior for the rate-matching pattern is not changed*
		- *UE behavior is specified for the case where a UE identifies overlaps between its PDSCH DMRS and the rate-matching pattern*
	+ *The number M of the rate matching patterns that can overlap with DMRS is limited*
	+ *The maximum number of rate matching patterns configurable to a UE, including both the original RB-symbol level rate-matching patterns and the rate-matching patterns that may overlap with DMRS, is the same as Rel-15*
	+ *Applicable for both PDSCH mapping Type A and Type-B*

*Note: The case of wideband PRG is not in scope of this Rel-16 TEI proposal.**Note: The RE-level rate-matching is not in scope of this Rel-16 TEI proposal.* |

As described in [8], RAN1 had discussed on PDSCH rate matching regarding the conditions of “collision between PDSCH DMRS REs and REs not available for PDSCH” as part of NR TEI in RAN1#98, #98bis, and #99 meetings. Since companies’ views could not be converged in those meetings, RAN1 should not spend further time and resource for this issue in current situation where Rel-16 stabilization especially for UE features is prioritized.

Based on above, only if there has been sufficient offline discussion among companies to converge their views on the issue for conditions of rate matching pattern overlapping with PDSCH DMRS symbols, the issue should be discussed in RAN1#101-e meeting.

# **References**

[1] R1-2003423 Remaining issues on Half-Duplex Operation in CA vivo

[2] R1-2003492 Remaining issues on CLI ZTE

[3] R1-2003610 Remaining issues of half-duplex operation in CA CATT

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[5] R1-2003763 Maintenance of aperiodic CSI-RS triggering with beam switching timing of 224 and 336 Intel Corporation

[6] R1-2003923 On ambiguous TBS due to ambiguity of Ninfo NEC

[7] R1-2004259 On remaining issues of HD UE feature Nokia, Nokia Shanghai Bell

[8] R1-2004604 Discussion on the conditions of rate matching pattern overlapping with PDSCH DMRS symbols Huawei, HiSilicon

[9] R1-2004642 Remaining issue for Rel-16 maintenance Ericsson