**3GPP TSG RAN WG1 #100bis-e R1-2002461**

e-Meeting, April 20th – 30th, 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.

For NR Rel-16 TEI, RAN1 has endorsed following proposals.

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| * + DSS (multiple LTE CRS rate matching patterns)   + CSI trigger states containing non-active BWP   + Aperiodic CSI-RS Triggering for UE reporting beamSwitchTiming values of 224 and 336   + TRS for FR1   + Enable gNB to configure downgrading configuration of SRS for antenna switching   + Half-duplex operation in CA (as a working assumption)   + RACH configuration considering TDD configuration for FR1 |

Based on contributions in AI 7.2.12, following six issues are identified. Note that [8] discusses HARQ/CSI enhancements according to Rel-17 WID on URLLC/IIoT enhancements, i.e., related to neither TEI-16 nor CLI/RIM.

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

As a feature lead’s opinion according to the contribution reviewing, following is the suggested list of issues to be discussed and priority order. The feature lead basically thinks that all above issues are worth discussing, but considering the current situation that Rel-16 stabilization is prioritized, issues for maintenance of already endorsed TEI items and CLI/RIM WI should be prioritized over other issues.

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

**1st priority issues:**

* **Remaining issues for CLI measurement and reporting**
  + **Whether/how to capture agreed UE behavior on SRS-RSRP measurement in TS38.214**
    - **TPs in R1-2001589 and R1-2001957 are starting points for the discussion**
  + **Whether/how to capture agreed UE behavior on CLI-RSSI measurement in TS38.331**
    - **TP in R1-2001957 is a starting point for the discussion**
* **Remaining issue for aperiodic CSI-RS triggering with beam switching timing of 224 and 336**
  + **Whether/how to introduce new Rel-16 capability for indicating beam switching timing of 224 and 336**
    - **TP and proposed capability in R1-2002027 are starting points for the discussion**
* **Remaining issues for half-duplex operation in CA**
  + **Whether/how to capture the agreement which is not correctly reflected in TS38.213**
    - **TPs in R1-2002074 and R1-2002229 are starting points for the discussion**
  + **Whether/how to cover mixed numerology case**
    - **TP in R1-2002229 is a starting point for the discussion**

**2nd priority issues:**

* **Issue for TRS bandwidth**
  + **Whether/how to solve the issue that an operator may not be able to deploy NR with reduced BW between 5MHz and 10MHz due to necessity to transmit TRS within whole 10MHz BWP, i.e. 52PRB**
* **Issue for intermediate number of information bits**
  + **Whether/how to solve the issue that it is not clear whether Ninfo is an integer number or a floating point number**
* **Issue for conditions of rate matching pattern overlapping with PDSCH DMRS symbols**
  + **Whether/how to solve the issues discussed in R1-2002679**

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

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| Company | Comment |
| Nokia | Our opinion is that TRS bandwidth issue is of high priority and should have an email thread in RAN1#100be. It is clear that R16 UEs are mandated to support only BWPs corresponding to nominal channel BW. Issue is clear. Moreover, this is critical deployment scenario, therefore, question is not “whether to solve” but “how to solve” and for that technical discussion is needed. |
| ZTE | We are okay with the priority in general. From our perspective, 2nd priority issues can be discussed in next meeting instead, depending on the overall email thread situation in next meeting. Regarding the 2nd issue of the first priority issues, it is related to UE capability. Hence it is suggested to be treated under UE feature AI to avoid duplicated discussion. |
| Ericsson | Share the same opinion as Nokia on TRS bandwidth. This topic falls under 3GPP obligation and commitment to in Rel-16 address learnings from early deployments and is more important, and should have higher priority, than any of the issues listed above as high priority. |
| Samsung | On the priority of TRS bandwidth, we share the same view with Nokia and Ericsson. |
| Huawei, HiSilicon | At first, we support Feature lead’s guideline to handle Rel-16 endorsed TEIs first but not to treat or open other TEIs.  For the issue of TRS bandwidth, we do not think it need to be discussed. In the current spec, it is clear that the TRS bandwidth (TS38.213) can be min(52, NBWP) or NBWP size. In the case that 7MHz (5MHz~10MHz), the TRS bandwidth can be equal to NBWP size. So, there is no issue at all.  Then, for the concern that bandwidth configuration is nominal or non-nominal, I copied the agreement in RAN4 (R4-1910522) as follows:  *RAN4 agreed that “UE can access the cell if UE supports a channel bandwidth which is equal to or narrower than the channel bandwidth in SIB1 and is equal to or wider than the initial BWP-bandwidth.”*  ***BWP-bandwidth can be configured with any number of RBs equal to or narrower than RB size of the supported channel bandwidths****.*  *Although the core requirement is applied to any RB configuration, it is noted that only the set of supported channel bandwidths are included in conformance tests due to the test coverage limitation.*  From the agreement, it is clear that NBWP can be any number of RBs, not restricted as nominal cases. So, we do not see any problems on current specs. |
| Verizon | We second Ericsson's opinion that we should try to seek a pragmatic solution during RAN1#100b-e.  We have a critical situation where we have to keep some legacy narrowband systems around for a long time, due to our past long-term customer commitment. As of today, it looks like we may have to sacrifice a wide NR band just to do that - which is inconceivable, but unfortunately, the reality of the state of industry.  We can argue that RAN1 supports all non-nominal BWPs, and we can just ask RAN4 to specify their requirements accordingly. But RAN4 needs to do the bandwidth one by one, delivering the whole set of the requirements for a proposed BW in the same way as it did for nominal BW. Not only does it take time, but if operators don't have consensus on.one or a few bandwidths, their work is just not going to get started.  Ideally it would be very desirable to seek a relatively easier-to-manage RAN1 solution that keeps it in the "signaling/control" domain and does not need RAN4 to go the full length to redefine requirements, e.g., rx performance of a 7MHz control channel, and then the set for maybe 8.5MHz and so on.   So we are looking for a pragmatic approach, not just from RAN1 point of view but from end user point of view. As a user, we are neutral to all technical solutions but we want one of them that we can implement.  Another reason why we can't delay it further is that without a solution, there will be more and more NR UEs coming to the market that will become "legacy" when eventually a solution to this is found. And our experience is that such "legacy" UEs are a headache to the operation, as we are bound by our commitment to customers.  Thank you all, and please kindly at least allow this topic to be discussed next week - let's give it a try please. This is indeed an urgent need and we appreciate the support from the vendor community. |

# **Updated FL Proposals**

The moderator recommends following email discussions for FL Proposals 1, 2 and 3. Note that the remaining issue for aperiodic CSI-RS triggering with beam switching timing (i.e., whether/how to introduce FG14-7) is to be discussed in UE feature agenda.

**FL Proposal 1: Email discussion/approval on remaining issues for CLI measurement and reporting (20th-24th April)**

* **Whether/how to capture agreed UE behavior on SRS-RSRP measurement in TS38.214**
  + **TPs in R1-2001589 and R1-2001957 are starting points for the discussion**
* **Whether/how to capture agreed UE behavior on CLI-RSSI measurement in TS38.331**
  + **TP in R1-2001957 is a starting point for the discussion**

**FL Proposal 2: Email discussion/approval on remaining issues for half-duplex operation in CA (20th-24th April)**

* **Whether/how to capture the agreement which is not correctly reflected in TS38.213**
  + **TPs in R1-2002074 and R1-2002229 are starting points for the discussion**
* **Whether/how to cover mixed numerology case**
  + **TP in R1-2002229 is a starting point for the discussion**

**FL Proposal 3: Email discussion/approval on issue for TRS bandwidth (20th-24th April)**

* **Whether/how to solve the issue that an operator may not be able to deploy NR with reduced BW between 5MHz and 10MHz due to necessity to transmit TRS within whole 10MHz BWP, i.e. 52PRB**

# **Remaining issue for CLI measurement and reporting**

In [1], the following remaining issue regarding CLI measurement and reporting is identified.

* The RAN1#100-e agreement of UE measurement behavior corresponding to SRS-RSRP measurement resource configuration should be captured in 38.214.

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| In our opinion, the agreement of UE measurement behaviour corresponding to SRS-RSRP measurement resource configuration should also be captured in 38.214. The following TP in TS 38.214 are proposed to capture the assumption on SRS-RSRP measurement.  **Proposal 1: Adopt the following text proposal.**  ------------------------------------------- < Start of text proposal for 38.214 [1]> ----------------------------------------------  5.1.6.4 SRS reception procedure for CLI  The 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.  -------------------------------------------------- < End of text proposal> ----------------------------------------------------- |

In [2], the following remaining issues regarding CLI measurement and reporting are identified.

* The RAN1#100-e agreement of UE measurement behavior corresponding to CLI-RSSI measurement resource configuration should be captured in 38.331. RAN1 should send LS to RAN2 for updating the description of Reference-Subcarrier-Spacing for CLI-RSSI measurement.
* The RAN1#100-e agreement of UE measurement behavior corresponding to SRS-RSRP measurement resource configuration should be captured in 38.214.

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| In addition, it seems necessity to capture UE behavior for CLI-RSSI measurement and SRS-RSRP measurement. UE assumption for CLI-RSSI measurement can be captured in the description of Reference-Subcarrier-Spacing for CLI-RSSI measurement resource in RRC parameter. Also, UE behavior for SRS-RSRP measurement can be reflected in TS38.214.  ***Proposal 1:***   * Capture UE behavior for CLI-RSSI measurement in the description of RRC parameter (i.e., Reference-Subcarrier-Spacing for CLI-RSSI measurement resource) in TS38.331. Send LS to RAN2 for updating the description of Reference-Subcarrier-Spacing for CLI-RSSI measurement.  |  |  | | --- | --- | | **Parameter name in text** | **Description** | | Reference-Subcarrier-Spacing | Reference subcarrier spacing for CLI-RSSI measurement  UE performs CLI-RSSI measurement with the SCS of the active bandwidth part within the configured CLI-RSSI resource in the active BWP regardless of the reference SCS of the measurement resource. |   ***Proposal 2:***   * Capture UE behavior for SRS-RSRP measurement in TS38.214   ============ Start of Text Proposal for TS38.214 [3] ==================  **5.1.6.4 SRS reception procedure for CLI**  The 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 more than 32 SRS resources, and the UE is not expected to receive more than 8 SRS resources in a slot. When SRS-RSRP measurement resource is fully confined within BW of DL active BWP, UE operates SRS-RSRP measurement using the SRS-RSRP measurement resource. Otherwise the UE does not operate SRS-RSRP measurement using the SRS-RSRP measurement resource.  ============ End of Text Proposal for TS38.214 ================== |

Based on above, following remaining issues for CLI measurement and reporting should be discussed in RAN1#100bis-e meeting.

* Whether/how to capture agreed UE behaviour on SRS-RSRP measurement in TS38.214
* Whether/how to capture agreed UE behaviour on CLI-RSSI measurement in TS38.331

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

In [3], 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. RAN1 should send LS to RAN2 for updating previous RAN1 agreement on this enhancement.

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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* to avoid possible ambiguity between Rel-15 and Rel-16.  **Proposal**:   * *Introduce Rel-16 capability indicating beam switching timing of 224 and 336 while keep Rel-15 capability and UE behaviour unchanged.* * *Mandate UE reporting both Rel-15 and Rel-16 capability of beam switching timing for the same band to report beam switching timing of 48 for Rel-15 to avoid ambiguity on the assumed threshold.* * *Send LS to RAN2 to update previous RAN1 agreement on the enhancement*   The TPs capturing the above proposals to TS 38.214 and TS 38.306 are provided below:   |  | | --- | | 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 | | --- | --- | --- | --- | --- | |

In AI7.2.11.12, there are several contributions discussing the necessity of new Rel-16 capability for indicating beam switching timing of 224 and 336 (FG14-7). [10], [11], [12] and [13] are supportive to introduce the new capability while [14] provides different view.

Based on above, following remaining issue for aperiodic CSI-RS triggering with beam switching timing of 224 and 336 should be discussed in RAN1#100bis-e meeting.

* Whether/how to introduce new Rel-16 capability for indicating beam switching timing of 224 and 336

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

In [4], the following remaining issues regarding half duplex operation in CA are identified.

* The agreement that half-duplex CA UE determines reference cell per symbol as a cell with the lowest ID among multiple serving cells in a band or band combination having direction determined by RRC D/U or semi SFI D/U is not correctly reflected and the meaning of reference cell has changed.
* Only one “and” exists in the “if” conditions, and the last condition should be satisfied for all the multiple serving cells.
* When transmission directions of multiple other cells are not aligned, UE cannot determine to follow the transmission direction of which cell.
* The agreements for inter-band CA case are not correctly captured in the specification.

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| According to the agreement, half-duplex CA UE determines reference cell per symbol as a cell with the lowest ID among multiple serving cells in a band or band combination having direction determined by RRC D/U or semi SFI D/U. However, this is not correctly reflected in the CR for TEI, the reference cell is defined as a cell with the smallest cell index among the multiple serving cells in the CR and the meaning of reference cell has changed compared with the agreement above. According to the email discussion after RAN1#99, to avoid the need of resolving the conflict among other cells, the reference cell should always have a direction determined by RRC D/U or semi SFI D/U.  In addition, the four conditions for reference cell determination should be satisfied at the same time but only one ‘and’ exists in the if conditions. Meanwhile, the last condition for reference cell determination should be satisfied for all the multiple serving cells. The same issue also exist in other if conditions for half-duplex operation in CA.  Hence, a text proposal is provided for 38.213 section 11.1 as below.  ***Proposal 1: Adopt the following corrections for reference cell determination to the*** ***half-duplex operation in CA.***  -------------------------------------------------- Start of text proposal ------------------------------------------------------  **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,  for a set of symbols of a slot that are indicated to the UE for reception of SS/PBCH blocks in any of multiple serving cells by *ssb-PositionsInBurst* in *SystemInformationBlockType1* or by *ssb-PositionsInBurst* in *ServingCellConfigCommon*, when provided to the UE, the UE does not transmit PUSCH, PUCCH, or PRACH in the slot if a transmission would overlap with any symbol from the set of symbols, and the UE does not transmit SRS in the set of symbols of the slot in any of multiple serving cells.  **\*\*\* 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 per symbol a reference cell as a cell with the smallest cell index among the multiple serving cells having direction determined to be  - 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  If a UE  - is configured with multiple serving cells in a frequency band 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 does not expect  - a symbol to be indicated as downlink or uplink on the reference cell and as uplink or downlink on another cell, respectively, by *tdd-UL-DL-ConfigurationCommon* or by *tdd-UL-DL-ConfigurationDedicated*,  - *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigDedicated* to indicate a symbol as downlink on the reference cell and to detect a DCI format scheduling a transmission on the symbol on another cell, and  - to be configured by higher layers to receive PDCCH, PDSCH, or CSI-RS on a flexible symbol on the reference cell and to detect a DCI format scheduling a transmission on the symbol on another cell.  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', 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  - UE assumes symbol 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 scheduled by a DCI format on a symbol of the other cell when the symbol is indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigDedicated* for the reference cell,  - is not required to receive a higher layer configured PDCCH, PDSCH, or CSI-RS on flexible symbols on the reference cell in a set of symbols, if the UE detects a DCI format scheduling a transmission on one or more symbols in the set of symbols on the other cell.  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 cell from 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  - does not expect *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* for the reference cell to indicate a symbol as uplink and to detect a DCI format scheduling a reception on the symbol on another cell  - does not expect to be configured by higher layers to transmit SRS, PUCCH, PUSCH, or PRACH on a flexible symbol on the reference cell and to detect a DCI format scheduling a reception on the symbol on another cell  - does not transmit a PUCCH, PUSCH or PRACH that is configured by higher layers on a set of symbols on another cell if at least one symbol from the set of symbols is indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* or is a symbol corresponding to a PDCCH, PDSCH, or CSI-RS reception that is configured by higher layers on the reference cell  - does not transmit a SRS that is configured by higher layers on a set of symbols on another cell if the set of symbols is indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* or corresponds to a PDCCH, PDSCH or CSI-RS reception that is configured by higher layers on the reference cell  - does not receive a PDCCH, PDSCH or CSI-RS that is configured by higher layers on a set of symbols on another cell if at least one symbol from the set of symbols is indicated as uplink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* or is a symbol corresponding to a SRS, PUCCH, PUSCH, or PRACH transmission that is configured by higher layers on the reference cell  - assumes a symbol indicated as downlink or uplink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* on another cell to be flexible, if the UE is respectively configured by higher layers to transmit SRS, PUCCH, PUSCH, or PRACH or to receive PDCCH, PDSCH, or CSI-RS on the reference cell  - does not expect to detect a first DCI format scheduling a transmission or reception on a symbol on a first cell and a second DCI format scheduling a reception or transmission on the symbol on a second cell, respectively  ----------------------------------------------------- End of text proposal ------------------------------------------------------  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   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **No** | **Ref cell** | **Other cell** | **UE behavior** | **Note** | | 3 | Semi SFI D | Dynamic U | Alt 1: Allowed to drop D for inter-band  Error 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-band  Error 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   |  |  |  |  | | --- | --- | --- | --- | | **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 2: 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 [5], the following remaining issues regarding half duplex operation in CA are identified.

* The agreement that half-duplex CA UE determines reference cell per symbol as a cell with the lowest ID among multiple serving cells in a band or band combination having direction determined by RRC D/U or semi SFI D/U is not correctly implemented.
* If the above agreement is correctly implemented, then 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

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| In RAN1#100e TP for this feature has been approved. Firstly, it seemed that the following agreement (highlighted in yellow) on determination of reference cell has not been correctly implemented in the TP  **Agreement:**   * *Half-duplex CA UE determines reference cell per symbol as a cell with the lowest cell ID among multiple serving cells in a band or band combination having direction determined by RRC D/U or semi SFI D/U* * *Note: this overrides earlier agreement ”Reference (Ref) cell is the cell with the lowest cell ID among cells: (i) within the band or band combination and (ii) with conflicting directions, and “Other cell” is any cell within the band or band combination other than the Ref cell. “* * *Note: Agreed cases 12, 14, 17 and 18 are not needed anymore* * *Note: Agreed cases 9 and 10 should apply to collisions between two cells irrespective of a cell being reference or other*   The cell configured with flexible symbol by semi SFI F should not be considered as reference cell, based on the above agreement. Otherwise, it would be necessecary to re-introduce following cases   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **No** | **Ref cell** | **Other cell** | **UE behavior** | **Note** | | 12 | Dynamic U | Semi SFI D | Allowed to drop D | Dropping on other cell | | 14 | Dynamic D | Semi SFI U | Allowed to drop U | Dropping on other cell | | 17 | Dynamic U | RRC D | Allowed to drop D | Dropping on other cell | | 18 | Dynamic D | RRC U | Allowed to drop U | Dropping on other cell |   **Proposal 2:** *Adopt the following TP for half-duplex feature to align specification with agreement.*   |  | | --- | | 11.1 Slot configuration  <unchanged text omitted >  If a 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 determines per symbol a reference cell as a cell with the smallest cell index among the multiple serving cells and determines a symbol on the reference cell to be~~  ~~- downlink, uplink, or flexible as indicated by~~ *~~tdd-UL-DL-ConfigurationCommon~~* ~~or~~ *~~tdd-UL-DL-ConfigurationDedicated~~*  ~~- flexible if~~ *~~tdd-UL-DL-ConfigurationCommon~~* ~~is not provided~~  ~~- 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~~  the UE determines a reference cell for a symbol, among serving cells where the symbol is configured as  - downlink, uplink as indicated by *tdd-UL-DL-ConfigurationCommon,* *tdd-UL-DL-ConfigurationDedicated,* or *tdd-UL-DL-ConfigDedicated-IAB-MT*  - uplink, if the symbol is flexible and the UE is configured to transmit SRS, PUCCH, PUSCH, or PRACH on the symbol, or  - downlink, if the symbol is flexible and the UE is configured to receive PDCCH, PDSCH or CSI-RS on the symbol,  as a cell with the smallest cell index. |   If the above TP is accepted, then 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 3:** *To support mixed numerology scenario for half-duplex feature, adopt the following TP (in magenta)*   |  | | --- | | 11.1 Slot configuration  <unchanged text omitted >  If a 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 determines per symbol a reference cell as a cell with the smallest cell index among the multiple serving cells and determines a symbol on the reference cell to be~~  ~~- downlink, uplink, or flexible as indicated by~~ *~~tdd-UL-DL-ConfigurationCommon~~* ~~or~~ *~~tdd-UL-DL-ConfigurationDedicated~~*  ~~- flexible if~~ *~~tdd-UL-DL-ConfigurationCommon~~* ~~is not provided~~  ~~- 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~~  the UE determines a reference cell for a symbol of the lowest sub-carrier spacing among multiple serving cells, where the symbol or at least one of overlapping symbols is configured as  - downlink, uplink as indicated by *tdd-UL-DL-ConfigurationCommon,* *tdd-UL-DL-ConfigurationDedicated,* or *tdd-UL-DL-ConfigDedicated-IAB-MT*  - uplink, if the symbol is flexible and the UE is configured to transmit SRS, PUCCH, PUSCH, or PRACH on the symbol, or  - downlink, if the symbol is flexible and the UE is configured to receive PDCCH, PDSCH or CSI-RS on the symbol,  as a cell with the smallest sub-carrier spacing first and the smallest cell index second. | |

Based on above, following remaining issues for half-duplex operation in CA should be discussed in RAN1#100bis-e meeting.

* Whether/how to capture the agreement which is not correctly reflected in TS38.213
* Whether/how to cover mixed numerology case

# **Issue for TRS bandwidth**

In [6], the following issues regarding TRS bandwidth is identified.

* An operator may not deploy R16 NR with reduced BW between 5MHz and 10MHz due to necessesity to transmit TRS within whole 10MHz BWP, i.e. 52PRB.
* If it is agreed to reduce the TRS RB size minimum requirement for 15 kHz carrier smaller or equal to 52 RB, the exact reduced size of TRS should be defined.

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| On a carrier smaller than 52 PRB, TRS need to span across whole BWP. In addition, R15 and also R16 UEs are mandated to support only BWP sizes corresponding to nominal channel BW, e.g. 5MHz or 10MHz. An operator may not deploy R16 NR with reduced BW between 5MHz and 10MHz due to necessesity to transmit TRS within whole 10MHz BWP, i.e. 52PRB.    **Figure 1 Illustration of intended operation**  To solve this issue, the following options were discussed in RAN1#99   * **Alt1:**  Reduce the TRS RB size minimum requirement for 15kHz carrier smaller or equal to 52 RB * **Alt1b**: Reduce the TRS RB size minimum requirement for 15kHz carrier smaller or equal to 52 RB and UE is not expected to receive on RBs of a BWP not containing TRS resources * **Alt2:**  Introduce R16 capability 14-x, which indicates the support of 34 PRB BWP size * **Alt3:** Send LS to RAN5 and CC RAN4 and ask RAN5 to add a demodulation test case for 34 PRB BWP size at least for Rel-16 UEs.   + No further RF requirement is added compared with Rel-15   No discussion was allowed in RAN1#100e to resolve this critical deployment case.  Unless BWPs with non-nominal size (i.e. other than nominal channel BW) become mandatory for all R16 UEs, we think that Alt1 is the cleanest and simplest option to solve the above issue with the following TP   |  | | --- | | TP for 38.214  5.1.6.1.1 CSI-RS for tracking  <unchanged text omitted >  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, as given by the higher layer parameter *freqBand* configured by *CSI-RS-ResourceMapping*, is the minimum of [32] and resource blocks, or is equal to resource blocks, 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.  <unchanged text omitted > |   What remains open is the exact reduced size of TRS. Size of 32 RBs should be able to accommodate the case above, however it would not be sufficient anymore for deployments with available BW smaller than 7MHz.  **Proposal 1:***To resolve critical NR deployment issue****,*** *Adopt Alt1 and corresponding enclosed Draft CR1 (including TP) co-sourced by several companies.* |

In [7], same view as in [6] is provided as below.

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| In RAN1#99, the issue of blanking the TRS bandwidth was discussed [1]. On carriers smaller than or equal to 52 resource blocks, the tracking reference signal (TRS) spans across whole bandwidth part bandwidth. With Rel-15 UE supporting only bandwidth part bandwidths equal to the nominal channel bandwidths as defined by RAN4, e.g. 5MHz and 10MHz, the TRS bandwidth is the same as the channel bandwidth. This means that an operator cannot deploy Rel-15 NR with a reduced bandwidth between 5MHz and 10MHz without the TRS interfering with transmissions outside the frequency part allocated to NR.  In order to avoid this, it was proposed to allow an additional signaling value of 32 RB as a valid bandwidth for carriers with 52 RBs or less. Additionally, in order to have maximum bandwidth available for scheduling of other channels, Alt1 from [1] should be selected.  Since the configuration of TRS is using the generic signaling for CSI-IM, no new signaling needs to be defined in Rel-16. No new signaling, also means that it would be possible for Rel-15 UEs to implement the change early allowing the deployment scenario in question to happen as soon as possible. From this perspective, it is also important that the agreement is made already in the RAN1#100bis-e and is not delayed to a later meeting. A joint company draft CR has been submitted in R1-12002229[2].  It is therefore proposed:  **Introduce a new allowed TRS bandwidths for carriers with less than or equal to 52 RBs as proposed in draft CR in R1-12002229** |

In [5], different view from [6] and [7] on how to solve the issue is provided as below.

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| 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. However, we understand that companies have no consensus on the support of non-nominal BWP sizes in Rel-15 according to the LS (R1-1909900). Therefore, we proposed the following options for companies to discuss to resolve the issues.   * Option #1: All Rel-16 UEs are required to support BWP sizes from 2 to 273 PRBs in FR1 and from 2 to 264 PRBs in FR2   + No new RF requirements for BWP sizes other than RAN4-defined UE channel bandwidths are needed * Option #2: 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 preference is Option #1 because it’s a more clean & natural way to support the deployment in Figure 1. However, Option #2 is acceptable if companies still don’t have consensus on Option #1. In order to avoid potential comebacks for other carrier bandwidth sizes, we slightly modify the proposal in R1-2001121 as Option #2. 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: All Rel-16 UEs are required to support BWP sizes from 2 to 273 PRBs in FR1 and from 2 to 264 PRBs in FR2**   + **No new RF requirements for BWP sizes other than RAN4-defined UE channel bandwidths are needed** * **Option #2: 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 #1 is adopted, adopt one of the following alternatives.**   * **Alt. #1: Capture the following conclusion in RAN1 chairman notes**   + **All Rel-16 UEs are required to support BWP sizes from 2 to 273 PRBs in FR1 and from 2 to 264 PRBs in FR2** * **Alt. #2: Adopt the following TP for TS38.213.**   **-----------------Begin of Text Proposal-------------------------------**  12 Bandwidth part operation  <Omitted>  For each DL BWP or UL BWP in a set of DL BWPs or UL BWPs, respectively, the UE is provided the following parameters for the serving cell as defined in [4, TS 38.211] or [6, TS 38.214]:  - a SCS by *subcarrierSpacing*  - a cyclic prefix by *cyclicPrefix*  - a common RB  and a number of contiguous RBs  provided by *locationAndBandwidth* that indicates an offset  and a length  as RIV according to [6, TS 38.214], setting , and a value  provided by *offsetToCarrier* for the *subcarrierSpacing*, where  is any integer value between 1 and 275.  - an index in the set of DL BWPs or UL BWPs by respective *BWP-Id*  - a set of BWP-common and a set of BWP-dedicated parameters by *BWP-DownlinkCommon* and *BWP-DownlinkDedicated* for the DL BWP, or *BWP-UplinkCommon* and *BWP-UplinkDedicated* for the UL BWP [12, TS 38.331]  For unpaired spectrum operation, a DL BWP from the set of configured DL BWPs with index provided by *BWP-Id* is linked with an UL BWP from the set of configured UL BWPs with index provided by *BWP-Id* when the DL BWP index and the UL BWP index are same. For unpaired spectrum operation, a UE does not expect to receive a configuration where the center frequency for a DL BWP is different than the center frequency for an UL BWP when the *BWP-Id* of the DL BWP is same as the *BWP-Id* of the UL BWP.  <Omitted>  **-----------------End of Text Proposal-------------------------------**  **Proposal #3: If Option #2 is adopted, adopt the following TP for TS38.214.**  **-----------------Begin of Text Proposal-------------------------------**  5.1.6.1.1 CSI-RS for tracking  A 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-------------------------------** |

Based on above, following issue for TRS bandwidth should be discussed in RAN1#100bis-e meeting as second priority since this issue does not belong to any of already endorsed TEI proposals and there are different views among companies for the solution.

* Whether/how to solve the issue that an operator may not be able to deploy NR with reduced BW between 5MHz and 10MHz due to necessity to transmit TRS within whole 10MHz BWP, i.e. 52PRB

# **Issue for intermediate number of information bits**

In [7], the following issue regarding intermediate number of information bits is identified.

* It is not clear whether Ninfo is an integer number or a floating point number even in Rel-16. The transmission will fail if gNB and UE are using different equations for TBS determination.

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| The N\_info in the 5.1.3.2 was discussed at Reno RAN1#99 meeting. The current specification text in 38.214, clause 5.1.3.2 states:  2) Intermediate number of information bits (*Ninfo*) is obtained by  From the equation it is clear that N\_info is a floating-point variable, while the text preceding the equation can be read as N\_info being an integer. Consequently, there are different UEs out there, some “integer” UEs and some “float” UEs, which makes any clarification in Rel-15 cumbersome. Even within one company, different group has different interpretations.  This was discussed online with the conclusion.  **Conclusion**  On the issue of ambiguity with regards to the definition of N\_info, there is no consensus in RAN1 to make specification change in Rel-15. For further discussion on whether to fix this in Rel-16.    One of these alternatives shall be decided in Rel-16.   1. N\_info is a floating point number. Revise the specification text to   Intermediate number of information bits (Ninfo) is obtained by The quantity  .   1. N\_info is an integer. Revise the specification text to   Intermediate number of information bits (Ninfo) is obtained by  N_"info" =⌊N_"RE"  RQ_m υ⌋.  Technically, selecting either “float” or “floor” can work for TBS size determination. However, it is important for gNB and UE to implement same equation. If a scheduling combination hits a N\_info value between 3824 and 3825, the transmission will fail if gNB and UE are using different equations.  **Selecting either “floor” or “float” can work for TBS size determination.**  **RAN1 make decision and select one of the alternatives.**  Though not fully investigated, we have the impression that there’s more “floor” UEs than the “float” UEs in the current NR network. It’s a bit unfortunate situation but we would suggest a solution that we believe have minimum impact to the existing NR deployment. And we are open for the other alternative also as we are fully aware the original intension is to use float.  **There are probably more “floor” UEs than the “float” UEs in the market.**  **Based on the observation, we have the following text proposal.**  ---------------------------- Start of proposed TP for 38.214 --------------------------------------------  --- Unchanged text omitted ---------  2) Intermediate number of information bits (*Ninfo*) is obtained by .  If  Use step 3 as the next step of the TBS determination  else  Use step 4 as the next step of the TBS determination  end if  3) When , TBS is determined as follows  ---------------------------- End of proposed TP for 38.214 --------------------------------------------  Once the decision is made in RAN1 for Rel-16, it can be applied for Rel-15 implementation.  **The Rel-16 decision on N\_info equation between 3828 and 3825 can be applied for Rel-15.** |

In [1], different view from [7] on the issue is provided as below..

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| However, in 3GPP RAN1#99, some companies thought that the definition of *Ninfo* implicitly denotes hard bit and a floor operation is additionally needed after the multiplication of *NRE*, *R*, *Qm* and *v*. The views on whether *Ninfo* is an integer number or a floating-point number differ in companies, which may lead to different understandings of TBS between gNodeBs and UEs [5].  For example, assume an MCS entry of *IMCS*=5 in MCS index table 1 for PDSCH in [1], *Qm*=2, R=379/1024, *NRE*=5166, *v*=1, then *NRE\*R\*Qm\*v* = 3824.05078125. If the *Ninfo* is considered as an integer, then TBS=3824. Otherwise, i.e., *Ninfo* is a floating-point number, TBS=3840. It is easy to conclude that when the *Ninfo* is larger than 3824 and smaller than 3825, the two understandings of calculating *Ninfo* will result in two different TBSs as different steps of TBS determination are used.  **Observation 1**: The ambiguity of the intermediate number of information bits exists only when it is larger than 3824 and smaller than 3825.  However, after the discussion, there was no consensus in RAN1 and the conclusion was reached as follows.   |  | | --- | | **Conclusion in RAN1 #99**  On the issue of ambiguity with regards to the definition of N\_info, there is no consensus in RAN1 to make specification change in Rel-15. For further discussion on whether to fix this in Rel-16. |   In the 3GPP RAN5 #86 e-meeting, the issue was discussed again. The conclusion was finally reached as follows[6].   |  | | --- | | **Conclusion in RAN5 #86-e**  RAN5 accepted the solution 'skip the specific TBS size'. Proponents to submit CRs to RAN5#87 meeting to introduce this solution into test specifications. TTCN implementation shall be dependent on prose update. |   Since RAN5 has concluded to skip the specific TBSs, it is not necessary for RAN1 to consider the ambiguity issue of the intermediate number of information bits in Rel-15 and Rel-16 NR any more.  **Observation 2:** RAN5 concluded to resolve the ambiguity issue of the intermediate number of information bits by skipping the *Ninfo*in the range from 3824 to 3825.  **Proposal 2:**Since the ambiguity issue of the intermediate number of information bits can be avoided by implementation, RAN1 does not need to consider it in NR Rel-15 and Rel-16 .  **Proposal 3:**For infrastructure vendors, it is suggested that the cases in which *Ninfo* is larger than 3824 and smaller than 3825 should be skipped by scheduling. |

Based on above, following issue for intermediate number of information bits should be discussed in RAN1#100bis-e meeting as second priority since this issue does not belong to any of already endorsed TEI proposals and there are different views among companies for the solution.

* Whether/how to solve the issue that it is not clear whether Ninfo is an integer number or a floating point number

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

In [9], 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.   |  | | --- | | 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 [9], 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#100bis-e meeting as second priority since this issue does not belong to any of already endorsed TEI proposals.

# **References**

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[6] R1-2002229 On remaining NR TEI issues Nokia, Nokia Shanghai Bell

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[8] R1-2002355 Considerations on HARQ/CSI enhancements Apple

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[11] R1-2001834 Views on Rel-16 UE features for NR TEIs MediaTek Inc.

[12] R1-2002025 UE features for NR TEI Intel Corporation

[13] R1-2002280 UE features for TEIs Ericsson

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