**3GPP TSG RAN WG1 Meeting #100bis-e R1-2002688**

**E-meeting, April 20-30, 2020**

**Agenda Item: 7.2.5.1**

**Source: Moderator (Huawei)**

**Title: Feature lead summary#1 on PDCCH enhancements**

**Document for: Discussion and Decision**

# Introduction

In the RAN1 #99 meeting, the WID [1] on Physical Layer Enhancements for NR URLLC was concluded. In the RAN1#100bis-e meeting, remaining open issues and corrections will be discussed.

This document summarizes the key issues discussed under agenda item 7.2.5.1 based on the views in [2][3][4][5][6][7][8][9][10][11][12][13][14][15][16][17][18][19][20][21][22][23], and aims to identify a set of critical issues for RAN1#100bis-e email discussion.

# Summary of issues raised for PDCCH enhancements

This section summarize the issues raised by companies on PDCCH enhancements, among which a set of issues can be identified for RAN1#100bis-e email discussions per the guidance from Chairman.

Recommendation on the email threads and scope are given in section 2.1 and the summary of detailed issues are given in section 2.2.

## Recommendation for the scope of email threads

Based on the summary of issues in section 2.2, the following recommendation are made for the scope of email threads. Please note that in general the issues for DCI format design are postponed to next meeting, since the issues for enhanced PDCCH monitoring capability are more urgent to address considering the potential impact on UE feature and/or may extend more than one meetings. **A few easy issues for DCI format designs are recommended to be discussed with the issues for enhanced PDCCH monitoring capability**, probably can cheer up all of us among the tough issues. Note that we had intensive discussion in RAN1#100-e on most issues under the proposed email discussion #2 and #3.

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**Email discussion #1**

Email discussion/approval on remaining issues on enhanced PDCCH monitoring capability:

* **Issue B-1**: The per-CC limit on the maximum number of non-overlapping CCEs per monitoring span for (2, 2) and (4, 3)
* **Issue B-2**: The per-CC limit on the maximum number of monitored PDCCH candidates per monitoring span
* **Issue B-3**: Capability on the number of CCs with Rel-16 monitoring capability

**Email discussion #2**

Email discussion/approval on remaining issues on scaling PDCCH monitoring capability and corrections on TCI and search space sharing:

* **Issue C-1**: Definition of “aligned spans” and “non-aligned spans”
* **Issue C-2**: Scale the monitoring capability for “non-aligned spans” case
* **Issue A-13 & Issue A-14**: Corrections on TCI and search space sharing

**Email discussion #3**

Email discussion/approval on remaining issues on PDCCH overbooking/dropping and corrections on DCI format 0\_2/1\_2:

* **Issue D-1**: Span(s) for PDCCH overbooking/dropping
* **Issue D-2**: How to perform PDCCH dropping in a span
* **Issue A-5 & Issue A-8 & Issue A-9**: Corrections on DCI format 0\_2/1\_2

In addition, issue B-4 was discussed in RAN1#100-e but not included in the end. Since it may have RRC impact, companies please also provide your views on whether to include B-4 in one of the above email threads.

Companies are encouraged to provide views on the scope of the email threads.

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##  Summary of detailed issues

**Issues raised on DCI format design**

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| **Issue #** | **Description** | **Source** | **Recommended handling**  |
| A-1 | **DCI size alignment in TS 38.212** * *If both formats 0\_1/1\_1 and 0\_2/1\_2 are configured to monitor in USS, their size should be made distinguishable*
* *Other extension due to the introduction of DCI format 0\_2/1\_2*

*Note: Details seen in section 3* | Ericsson [7]Huawei/HiSi [2]Vivo [4]Nokia [5]MTK [9]LG [10]CATT [12]Samsung [13]Intel [11]Spreadtrum [14]Qualcomm [21]NTT DCM [19]ZTE [3]Panasonic [16]FUTUREWEI [23] | Postpone the discussion to next meeting **Reason:**1. Time limit for email discussion
2. May need some discussion before being able to conclude
 |
| A-2  | **Priority indication via DCI format 0\_1/1\_1 and 0\_2/1\_2** * *How to determine the priority of transmissions scheduled by the DCI formats 0\_1/1\_1/0\_2/1\_2 for a UE that doesn’t support a DCI format scheduling PDSCH with different HARQ-ACK priorities or PUSCH with different priorities when both DCI format 0\_1/1\_1 and DCI format 0\_2/1\_2 are configured to monitor?*

*Note: Details seen in section 3* | Intel [12]Qualcomm [19]Samsung [13]Vivo [4] | Note: To be discussed under UCI enhancements agenda as agreed in RAN1#100-e?**Reason:**1. *May have RRC impact depending on the solutions*

 |
| A-3 | Determination of DCI field sizes for the case of two HARQ-ACK codebooks * *Whether to confirm the working assumption from RAN1#99 with or without updates*
 | Ericsson [7]Vivo [4]Nokia [5]CATT [12]Samsung [13]LG [10] | Postpone the discussion to next meeting **Reason:**1. Time limit for email discussion
2. May need some discussion before being able to conclude
 |
| A-4 | Changing the candidate RV values from {0, 3} to {0, 2} in case of 1 bit for Redundancy version for DCI format 0\_2  | Ericsson [2]Samsung [13] | Postpone the discussion to next meeting **Reason:**1. Time limit for email discussion
2. Belongs to optimization
 |
| A-5 | Whether to introduce new RRC parameters to configure the scheduling cell index corresponding to DCI format 1\_2 and 0\_2  | Qualcomm [19] | Included in email discussion #3 together with PDCCH monitoring overbooking and dropping**Reason:**1. May have impact on RRC parameter
2. Should be an easy issue
 |
| A-6  | A-6-1: Correction to DMRS reception procedure for PDSCH scheduled by DCI formats 1\_2 (38.214, Sec. 5.1.3.2 & 5.1.6.2)A-6-2: Correction to DMRS transmission procedure for PUSCH scheduled by DCI format 0\_2 (38.214, Sec. 6.1.4.2 & 6.2.2) | Nokia [5]CATT [12] | To be discussed under eCG enhancements agenda?**Reason:**1. *Similar issue as issue #1 in eCG summary*

Note: If companies prefer to keep it here, we can discuss it in the next meeting  |
| A-7 | Issue A-7-1:Missing PTRS transmission procedure for PUSCH scheduled by DCI format 0\_1 & 0\_2 (38.214 - Sec. 6.2.3 & 6.2.3.1, 38.212 – Sec. 7.3.1.1.2 & 7.3.1.1.3)Issue A-7-2: Missing PTRS reception procedure for PDSCH scheduled by DCI formats 1\_2 (38.214, Sec. 5.1.6.2 & 5.1.6.3) | Nokia [5] | To be discussed under eCG enhancements agenda?**Reason:** Similar as A-6 |
| A-8 | Correction to FH field size definition for DCI format 0\_2 (38.212, Sec. 7.3.1.1.3) | Nokia [5] | Included in email discussion #3 together with PDCCH monitoring overbooking and dropping**Reason:**1. An easy issue to address
 |
| A-9 | Correction to PDSCH TDRA for DCI formats 1\_2 (38.214, Sec. 5.1.2.1) | Nokia [5] | Included in email discussion #3 together with PDCCH monitoring overbooking and dropping**Reason:**1. An easy issue to address
 |
| A-10 | Remove CBG PUSCH additions to DCI format 0\_1 (38.212, Sec. 7.3.1.1.2) | Nokia [5]LG [10] | Postpone the discussion to next meeting **Reason:**1. Time limit for email discussion
2. It is related to issue A-3
 |
| A-11 | Whether to add Pi/2-BPSK for the new DMRS and DCI format 0\_2 | Qualcomm [19] | Postpone the discussion to next meeting **Reason:**1. Time limit for email discussion
2. May need some discussion before being able to conclude
 |
| A-12 | PUCCH resource determination for reduced size of PRI field | Spreadtrum [14] | Postpone the discussion to next meeting **Reason:**1. Time limit for email discussion
2. May need some discussion before being able to conclude
 |
| A-13 | Correction on missing case of PUSCH release for search space sharing | Sharp [17] | Included in email discussion #2 together with scaling PDCCH monitoring capability**Reason:**An easy issue to address |
| A-14 | Correction on Transmission configuration indication in DCI format 1\_2 | ASUSTeK [20] | Included in email discussion #2 together with scaling PDCCH monitoring capability **Reason:**An easy issue to address |
| A-15 | Miscellaneous editorial corrections * *Remove bracket for the description for UL-SCH indicator field for DCI format 0\_2 in 38.212*
* *Remove underline from new RRC parameter in UE PDCCH procedures in 38.213*
* *Correct typo in Modulation order for PUSCH in 38.214*
* Align the RRC parameter names between TS 38.331 and TS 38.212
 | Nokia [5]CATT [12] | Postpone the discussion to next meeting or editor can capture it directly in the editor CR **Reason:**1. Time limit for email discussion
 |

**Issues raised on enhanced PDCCH monitoring capability**

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| **Issue #** | **Description** | **Source** | **Recommended handling**  |
| B-1 | The per-CC limit on the maximum number of non-overlapping CCEs per monitoring span for (2, 2) and (4, 3)*Note: Details seen in section 4.1* | Ericsson [7]Huawei/HiSi [2]Vivo [4]Nokia [5]MTK [9]OPPO [6]CATT [12]Samsung [13]Intel [11]Apple [15]Spreadtrum [14]Qualcomm [21]NTT DCM [19]ZTE [3]Panasonic [16] | Included in email discussion #1, to discuss the proposal 4.1-1 in section 4.1**Reason:**1. *Open issues need to be solved;*
2. *Proposed by Top 1 number of companies;*
3. *Diverse views from companies*
 |
| B-2 | The per-CC limit on the maximum number of monitored PDCCH candidates per monitoring span*Note: Details seen in section 4.1* | Ericsson [7]Huawei/HiSi [2]Vivo [4]Nokia [5]MTK [9]OPPO [6]CATT [12]Samsung [13]Intel [11]Apple [15]Spreadtrum [14]Qualcomm [21]NTT DCM [19]ZTE [3]Panasonic [16] | Included in email discussion #1, to discuss the proposal 4.1-2 in section 4.1**Reason:**1. *Open issues need to be solved;*
2. *Proposed by Top 1 number of companies;*
3. *Diverse views from companies*
 |
| B-3 | Capability on the number of CCs with Rel-16 monitoring capability | Ericsson [7]Huawei/HiSi [2]Nokia [5]MTK [9]Samsung [13]Apple [15]Spreadtrum [14]Qualcomm [21]NTT DCM [19]Panasonic [16]CATT [12] | Included in email discussion #1, to discuss the proposal 4.1-3 and proposal 4.1-4 in section 4.1**Reason:**1. *Open issues need to be solved;*
2. *Proposed by Top 3 number of companies;*
 |
| B-4 | *Further study whether/how to handle the issues due to switching between Rel-15 and Rel-16 PDCCH monitoring****Motivation****: Reduce large amount of RRC signaling overhead to enable an efficient operation* | Intel [11] | Included in email discussion #1? **Reason:**1. *May have impact on RRC parameter depending on the outcome, though it belongs to optimization.*
 |
|  |
| C-1 | How to define “aligned spans” and “non-aligned spans” for scaling PDCCH monitoring capability if the number of CCs configured is larger than the reported capability?  | Intel [11]MTK [9]CATT [12]ZTE [3]Spreadtrum [14]Samsung [13]Motorola [18] | Included in email discussion #2, to discuss the three questions in section 4.2**Reason:**1. *Open issues need to be solved;*
2. *Proposed by a number of companies;*
 |
| C-2 | How to scale the monitoring capability for “non-aligned spans” case if the number of CCs configured is larger than the reported capability?  | Intel [11]MTK [9]CATT [12]ZTE [3]Spreadtrum [14]Samsung [13]Motorola [18]Nokia [5]Qualcomm [21]CATT [12]Spreadtrum [14]Huawei/HiSi [2]Motorola [18]Quectel [8] | Included in email discussion #2, to discuss question 4.2-4 in section 4.2**Reason:**1. *Open issues need to be solved;*
2. *Proposed by a large number of companies;*
 |
| C-3 | Enhanced PDCCH monitoring capability for cross-carrier scheduling | Intel [11]Quectel [8] | Postpone to next meeting**Reason:**1. *Time limit;*
2. *Not many companies shared views*
 |
|  |
| D-1 | Span(s) for PDCCH overbooking/dropping | Ericsson [7]Huawei/HiSi [2]Vivo [4]Nokia [5]MTK [9]LG [10]CATT [12]Samsung [13]Apple [15]Spreadtrum [14]Qualcomm [21]NTT DCM [19]ZTE [3]Panasonic [16]Sharp [17]OPPO [6] | Included in email discussion #3, to discuss the question 4.2-5 in section 4.3**Reason:**1. *Open issues need to be solved;*
2. *Proposed by Top 2 number of companies;*
 |
| D-2 | How to perform PDCCH dropping in a span | Ericsson [7]Huawei/HiSi [2]Vivo [4]Nokia [5]MTK [9]CATT [12]Samsung [13]Apple [15]Spreadtrum [14]Qualcomm [21]NTT DCM [19]ZTE [3]Panasonic [16]Sharp [17]OPPO [6] | Included in email discussion #3, to discuss the proposal 4.3-1 in section 4.3**Reason:**1. *Open issues need to be solved;*
2. *Proposed by Top 2 number of companies;*
 |
|  |
| E-1 | Correction on determination of a combination (X, Y) for PDCCH monitoring in section 10.1 in TS 38.213  | Samsung [13] | Postpone to next meeting**Reason:**1. *Time limit;*
 |

# DCI format scheduling Rel-16 URLLC

Based on the contributions from companies, the following issues related to DCI format design are discussed.

**Issue A-1**: Further extension of DCI size alignment due to the introduction of DCI format 0\_2/1\_2?

In the current TS 38.212, DCI size alignment is extended due to the introduction of DCI format 0\_2/1\_2 with a few places in bracket due to lack of explicit agreements. WILUS (R1-2002634) provides a very nice table to summarize the DCI format sizes after each step as below:

**Table 1. DCI format size after each step (TS38.212 v16.1.0)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | After Step 0 | After Step 1 | After Step 2 | After Step 2A | After Step 3Check | After Step 4A | After Step 4B | After Step 4C |
| DCI format 0\_0 in CSS | **Size A**(padding) |  |  |  | 3 different DCI sizes with C-RNTI ? If no, go to step 4A~4COtherwise, finish | **Size A** | **Size A** | **Size A** |
| DCI format 1\_0 in CSS | **Size A**(truncation of FDRA field) |  |  |  | **Size A** | **Size A** | **Size A** |
| DCI format 0\_0 in USS |  | **Size B**(padding) |  |  | **Size B 🡪****Size A**  | **Size A**  | **Size A**  |
| DCI format 1\_0 in USS |  | **Size B**(padding) |  |  | **Size B 🡪****Size A** | **Size A** | **Size A** |
| DCI format 0\_1 |  |  | **Size C**(one bit insertion to differentiate Size B is needed) |  | **Size C** | **Size C** | **Size C 🡪****Size H** |
| DCI format 1\_1 |  |  | **Size D**(one bit insertion to differentiate Size B is needed) |  | **Size D** | **Size D** | **Size D 🡪****Size H** |
| DCI format 0\_2 |  |  |  | **Size E**(one bit insertion to differentiate Size B is needed) | **Size E** | **Size E 🡪****Size G** | **Size G** |
| DCI format 1\_2 |  |  |  | **Size F**(one bit insertion to differentiate Size B is needed) | **Size F** | **Size F 🡪****Size G** | **Size G** |

The remaining issue is how to distinguish the following cases.

**Case 1**: Fallback DCI format (0\_0, 1\_0) and new DCI format (0\_2, 1\_2)

**Case 2**: Non-fallback DCI format (0\_1, 1\_1) and new DCI format (0\_2, 1\_2)

The issue of DCI size alignment (i.e. appending zero padding bit(s) when necessary, or if gNB should guarantee the size to be different) has been discussed in the RAN1#100-e email discussion thread [100e-NR-L1enh\_URLLC\_PDCCH-01]. Unfortunately, consensus was not achieved.

Based on the inputs from the contributions, company positions are summarized as below:

* ***Option 1****:*
	+ *One zero-padding bit is added to DCI format 0\_2/1\_2 to differentiate DCI format 0\_2/1\_2 monitored in USS and DCI format 0\_0/1\_0 monitored in another USS.*
	+ *One zero-padding bit is added to DCI format 0\_1/1\_1 to differentiate DCI format 0\_2/1\_2 monitored in USS and DCI format 0\_1/1\_1 monitored in another USS.*
	+ *One zero-padding bit is added to DCI format 0\_1/1\_1 to differentiate DCI format 0\_2/1\_2 and DCI format 0\_1/1\_1 monitored in the same USS.*
	+ *Support: FUTUREWEI, WILUS, Ericsson, ZTE, Huawei/HiSilicon, Vivo, NTT DOCOMO, CATT, Spreadtrum, Panasonic*
	+ *Reason*
		- *Same principle in Rel-15 when both DCI formats 0\_0/1\_0 and DCI formats 0\_1/1\_1 are configured to be monitored in USS*
		- *Cons from option 2 and option 3*
			* *Having the UE supporting the legacy DCIs and the new DCIs with different mechanisms causes an implementation burden at the UE where you remove or bypass software checks which are already implemented for LTE and NR DCI*
			* *Restrictions on configured functionality: it is not guaranteed that there will be many fields which can be easily adjusted without impacting desired functionality*
* ***Option 2****:*
	+ *A UE is not expected to monitor a first decoding candidate with DCI format 0\_0/1\_0 and a second candidate with DCI format 0\_2/1\_2, where the two decoding candidates are mapped to the same resource and the DCI formats 0\_0/1\_0 and 0\_2/1\_2 have the same size.*
	+ *A UE is not expected to monitor a first decoding candidate with DCI format 0\_1/1\_1 and a second candidate with DCI format 0\_2/1\_2, where the two decoding candidates are mapped to the same resource and the DCI formats 0\_1/1\_1 and 0\_2/1\_2 have the same size.*
	+ *Support: Intel, Qualcomm, Huawei/HiSilicon, MTK, [Samsung], LG*
	+ *Reasons*
		- *It would be feasible to have different DCI sizes by gNB configuration*
* ***Option 3****: Supporting zero padding in case the DCI size budget is not exceeded (i.e. in steps 2A, 2B) and not supporting zero padding in case the DCI size budget is exceeded (i.e. in steps 4X), i.e.*
	+ *For step 2A, one zero-padding bit is added to DCI format 0\_2/1\_2 to differentiate DCI format 0\_2/1\_2 monitored in USS and DCI format 0\_0/1\_0 monitored in another USS, i.e. remove the brackets in step 2A of the DCI size alignment of Sec. 7.3.1.0 of TS 38.213.*
	+ *For step 2B, one zero-padding bit is added to DCI format 0\_1/1\_1 to differentiate DCI format 0\_2/1\_2 and DCI format 0\_1/1\_1 monitored in the same or a different USS when having the same size after step 2A, i.e. support the intention of step 2B as outlined in the RAN1#100-e FL summary in R1-2001404 with a slight change to include the same or different search space.*
	+ *For steps 4X, do not support zero padding to distinguish the DCI sizes as in case of Rel-15, i.e. no changes to steps 4A to 4C are seen as needed.*
	+ *Support: Nokia*

We had intensive discussion in RAN1#100-e meeting, and unfortunately we was not able to achieve agreement since both option 1 and option 2 got objections. From feature lead perspective, I do agree with some companies that this should not be considered as an objectionable issue. In addition, we did have tried different ways to progress the discussion but in the end stuck still. At this stage, I don’t have a good recommendation but go with the majority view, i.e. option 3.

***Proposal 3-1****:*

* + *One zero-padding bit is added to DCI format 0\_2/1\_2 to differentiate DCI format 0\_2/1\_2 monitored in USS and DCI format 0\_0/1\_0 monitored in another USS.*
	+ *One zero-padding bit is added to DCI format 0\_1/1\_1 to differentiate DCI format 0\_2/1\_2 monitored in USS and DCI format 0\_1/1\_1 monitored in another USS.*
	+ *One zero-padding bit is added to DCI format 0\_1/1\_1 to differentiate DCI format 0\_2/1\_2 and DCI format 0\_1/1\_1 monitored in the same USS*

Please provide your views here. Please also share if you think option 3 from Nokia can be a potential compromise solution if you don’t accept the above proposal.

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| *Company* | *View* |
| LG | For option 3, we think that the number of bits for zero padding may be more than one bit considering the key objective of zero padding is to avoid the same size between DCI formats. Secondly, we think this padding should be applied to DCI formats other than DCI format 0\_2/1\_2 considering the introduction of DCI format 0\_2/1\_2 comes from the effort to reduce the DCI size as possible. Also, no need for separate same or different USS here, anyhow a UE should be able to differentiate DCI formats regardless. Based on these observations, the final proposal should be something like:One or more zero padding bits are added to DCI format 0\_1/1\_1 to differentiate DCI format 0\_2/1\_2 monitored in USS and DCI format 0\_1/1\_1 monitored in same or another USS One or more zero padding bits are added to DCI format 0\_0/1\_0 to differentiate DCI format 0\_2/1\_2 monitored in USS and DCI format 0\_0/1\_0 monitored in another USSFor option 2, we think the proposal should be more generic (i.e., UE does not expect the same DCI size regardless of whether two DCI formats are mapped to the same resource or not). We slightly prefer option 2.  |
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**Issue A-2:** Priority indication via DCI format 0\_1/1\_1 and 0\_2/1\_2

The following agreements was made in RAN1#99:

**Agreement:**

*When both DCI format 0\_1/1\_1 and DCI format 0\_2/1\_2 are configured to be monitored per BWP, a DCI format (from the formats 0\_1/1\_1/0\_2/1\_2) can be used to schedule PDSCH with different HARQ-ACK priorities or PUSCH with different priorities.*

* *This feature is UE optional*

Both Intel and Qualcomm discuss how to determine the priority of transmissions scheduled by the DCI formats 0\_1/1\_1/0\_2/1\_2 for a UE that is not capable of supporting this feature. The following two options were proposed:

* ***Option 1****: Introduce new RRC parameters PriorityForDCIFormat0\_2 and PriorityForDCIFormat1\_2 to indicate the priority level of the PUSCH and PUCCH scheduled by DCI format 0\_2 and 1\_2.*
	+ *Support: Qualcomm*
* ***Option 2****: DCI formats 0\_1/1\_1 may only schedule PUSCH or HARQ-ACK transmission with priority index 0, while DCI formats 0\_2/1\_2 may still schedule PUSCH or HARQ-ACK transmission associated with either priority index 0 or 1.*
	+ *Support: Intel*
* ***Option 3****: DCI formats 0\_1/1\_1 only schedule PUSCH or HARQ-ACK transmission with priority index 0, while DCI formats 0\_2/1\_2 only schedule PUSCH or HARQ-ACK transmission associated with priority 1.*
	+ *Support: Samsung*
* ***Option 4****: For UE without priority indication capability, HARQ-ACK and PUSCH with lower priority is assumed*
	+ *Support: Vivo*

***Proposal 3-2****: Further discuss how to determine the priority of transmissions scheduled by the DCI formats 0\_1/1\_1/0\_2/1\_2 for a UE that doesn’t support a DCI format scheduling PDSCH with different HARQ-ACK priorities or PUSCH with different priorities, when both DCI format 0\_1/1\_1 and DCI format 0\_2/1\_2 are configured to monitor.*

Companies are encouraged to provide your preference and explain your reasons.

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| *Company* | *View* |
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**Issue A-3**: Determination of DCI field sizes for the case of two HARQ-ACK codebooks (38.212, Section 7.3.1.2.2 and 7.3.1.2.3)

 In the RAN1#99 meeting, the following agreement was made:

Working assumption:

When the UE is configured with two HARQ-ACK codebooks at least for the case when only one of the two DCI formats (1\_1 and 1\_2 for DL, 0\_1 and 0\_2 for UL), configured to support two HARQ-ACK codebooks, is configured to be monitored by the UE, the bit width of the following fields is the maximum of the bit widths for the two configurations corresponding to the two HARQ-ACK codebooks. The necessary number of most significant zero bits can be added to a field to achieve the alignment.

* PDSCH-to-HARQ\_feedback timing indicator
* Beta offset indicator
* DAI
* CBGTI & CBGFI (if configured for low priority HARQ-ACK codebook for DCI format 1\_1 and DCI format 0\_1)

Vivo and CATT propose to confirm the above working assumption. Some companies propose to confirm the above working assumptions with some updates as summarized as below:

**Proposed update #1**:

If the UE is configured with dynamic priority indication for DCI formats 0\_1, 0\_2, 1\_1 or 1\_2 (using *PriorityIndicator-ForDCIFormat0\_1/1\_1/0\_2/1\_2*)~~When the UE is configured with two HARQ-ACK codebooks at least for the case when only one of the two DCI formats (1\_1 and 1\_2 for DL, 0\_1 and 0\_2 for UL), configured to support two HARQ-ACK codebooks, is configured to be monitored by the UE,~~ the bit width of the following DCI fields is the maximum of the bit widths for the two configurations corresponding to the two HARQ-ACK codebooks. The necessary number of most significant zero bits can be added to a field to achieve the alignment.

* PDSCH-to-HARQ\_feedback timing indicator
* Beta offset indicator
* DAI
* CBGTI & CBGFI (if configured for the low priority HARQ-ACK codebook for DCI format 1\_1 and DCI format 0\_1)
	+ *Support: Nokia, Ericsson,*
	+ *Reasons:*
		- *Configuration of two HARQ-ACK codebooks does not necessarily mean that a particular DCI format can be used to schedule both HARQ-ACK priorities.*
		- *A more precise condition is to check whether the priority indicator field is present in the format, i.e. if more than one priority is scheduled by the respective DCI format as otherwise, the DCI format size may be unnecessarily large.*

Feature lead note: When the agreements and TS 38.212 was made, it was not clear whether configuring priority indicator in DCI is the only way to enable one DCI format scheduling different priorities, e.g. some RRC configured way can be considered.

**Proposed update #2**:

* *When the UE is configured with two HARQ-ACK codebooks and for the case when any of DCI formats (1\_1 and 1\_2 for DL, 0\_1 and 0\_2 for UL), configured to support two HARQ-ACK codebooks, is configured to be monitored by the UE, the bit width of the following fields is the maximum of the bit widths for the two configurations corresponding to the two HARQ-ACK codebooks. The necessary number of most significant zero bits can be added to a field to achieve the alignment.*
* *PDSCH-to-HARQ\_feedback timing indicator*
* *Beta offset indicator*
* *DAI*
* *CBGTI & CBGFI (if configured for the low priority HARQ-ACK codebook for DCI format 1\_1 and DCI format 0\_1)*
* *PRI*
	+ *Support: Vivo*
	+ *Reasons:*
		- *PUCCH resources are also separately configured for HARQ-ACK codebooks.*

**Proposed update #3**:

When the UE is configured with two HARQ-ACK codebooks ~~at least for the case when only one of the two DCI formats (1\_1 and 1\_2 for DL, 0\_1 and 0\_2 for UL), configured to support two HARQ-ACK codebooks, is configured to be monitored by the UE~~, the bit width of the following fields is the maximum of the bit widths for the two configurations corresponding to the two HARQ-ACK codebooks. ~~The necessary number of most significant zero bits can be added to a field to achieve the alignment.~~

* PDSCH-to-HARQ\_feedback timing indicator
* Beta offset indicator
* DAI
* CBGTI & CBGFI (if configured for low priority HARQ-ACK codebook for DCI format 1\_1 and DCI format 0\_1)
	+ *Support: Samsung*
	+ *Reasons:*
		- *It is unnecessary for the MSBs to have 0 value as then they are useless.*

**Proposed update #4**:

When the UE is configured with two HARQ-ACK codebooks at least for the case when only one of the two DCI formats (1\_1 and 1\_2 for DL, 0\_1 and 0\_2 for UL), configured to support two HARQ-ACK codebooks, is configured to be monitored by the UE, the bit width of the following fields is the maximum of the bit widths for the two configurations corresponding to the two HARQ-ACK codebooks. The necessary number of most significant zero bits can be added to a field to achieve the alignment.

* PDSCH-to-HARQ\_feedback timing indicator
* Beta offset indicator
* DAI
* CBGTI & CBGFI (if configured for the low priority HARQ-ACK codebook for DCI format 1\_1 ~~and DCI format 0\_1~~)
* PUCCH resource indicator
	+ *Support: LG*
	+ *Reasons:*
		- *The CBG operation for PUSCH is nothing to do with two HARQ-ACK codebook constructions.*

***Proposal 3-3****: Further study whether/how to confirm the following working assumption with or without any update.*

* + *FFS: Extend to the case that both R-15 and Rel-16 DCI formats can be used to schedule same priority traffic by deleting “at least for the case when only one of the two DCI formats (1\_1 and 1\_2 for DL, 0\_1 and 0\_2 for UL), configured to support two HARQ-ACK codebooks, is configured to be monitored by the UE”*
	+ *FFS: Change the condition to “If the UE is configured with dynamic priority indication for DCI formats 0\_1, 0\_2, 1\_1 or 1\_2 (using PriorityIndicator-ForDCIFormat0\_1/1\_1/0\_2/1\_2)”*
	+ *FFS: PUCCH resource indicator as one of the fields to be checked*
	+ *FFS: Change “CBGTI & CBGFI (if configured for the low priority HARQ-ACK codebook for DCI format 1\_1 and DCI format 0\_1” to “CBGTI & CBGFI (if configured for the low priority HARQ-ACK codebook for DCI format 1\_1 ~~and DCI format 0\_1~~”*

Working assumption:

When the UE is configured with two HARQ-ACK codebooks at least for the case when only one of the two DCI formats (1\_1 and 1\_2 for DL, 0\_1 and 0\_2 for UL), configured to support two HARQ-ACK codebooks, is configured to be monitored by the UE, the bit width of the following fields is the maximum of the bit widths for the two configurations corresponding to the two HARQ-ACK codebooks. The necessary number of most significant zero bits can be added to a field to achieve the alignment.

* PDSCH-to-HARQ\_feedback timing indicator
* Beta offset indicator
* DAI
* CBGTI & CBGFI (if configured for low priority HARQ-ACK codebook for DCI format 1\_1 and DCI format 0\_1)

Companies are encouraged to provide your preference and explain your reasons.

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| *Company* | *View* |
| LG | We are fine with the extension proposed by Samsung.  |
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**Issue A-4:** *Whether to change the candidate RV values from {0, 3} to {0, 2} in case of 1 bit for Redundancy version for DCI format 0\_2?*

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| *Ericsson R1-2001784*For DCI format 1\_2 scheduling PDSCH, if only one bit is signalled, the redundancy version to be applied is either 0 or 3. This is a reasonable choice for PDSCH since both RV 0 and 3 are self-decodable for high code rate, and error cases exist where the gNB cannot tell whether the UE received the first transmission and stored the corresponding soft values or not. This is not the case for PUSCH. If the UE does not transmit the PUSCH correctly due to a missed grant, it is possible for the gNB to detect this, e.g. by looking at the noise level estimate based on DMRS. In this case the gNB can schedule the retransmission using RV 0 (basically treating it as the first transmission), which gives better performance than using RV 3 for a first transmission. On the other hand, if the first PUSCH transmission is transmitted correctly, but not decoded at the gNB due to a noisy transmission, the gNB would like to schedule the retransmission using RV 2, and soft combine with the first transmission. This gives better performance than using RV 3, as can be seen in [7] where Figure 3 appears. For this case, LDPC base graph (BG) #1 is used for information block size of K=1056 bits, and two consecutive transmissions are soft combined before decoding. As can be observed from Figure 1, for medium to high code rates above 2/3 (=0.67), the difference between using RV 3 and RV 2 for the second transmission is more than 1.5 dB over an AWGN channel.Figure 3 Required SNR for decoding after two transmissions for different RV orders for BG1. K is the TBS including CRC bits.Dynamically scheduled PUSCH is a case where there is no ambiguity about whether transmission occurred, or which instance of a transmission occurred. Self-decodability is not important for an individual retransmission. Hence the gNB should be able to schedule for best performance, i.e. it should be able to signal RV 2.1. For dynamically scheduled PUSCH, there is no ambiguity at the gNB whether the first transmission occurred or not, and RV should be chosen to maximize performance.

The note above did not capture these aspects and thus cannot be used to conclude on the RV field for DCI format 0\_2. For performance reasons and for alignment with NR-U we have the following proposal. The text proposal for TS 38.212 is also provided below.1. When only one bit is used to signal RV in DCI format 0\_2, it indicates either RV 0 or RV 2.

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| **------------------ Text Proposal for 38.212 Section 7.3.1.1.3 ------------------**- Redundancy version – 0, 1 or 2 bits determined by higher layer parameter *NumberofbitsforRV-ForDCIFormat0\_2*- If 0 bit is configured, *rvid* to be applied is 0;- 1 bit according to Table ~~7.3.1.2.3-1~~ 7.3.1.1.2-34;- 2 bits according to Table 7.3.1.1.1-2. ----------------------------------------------End of proposed TP ---------------------------------------------------- |

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Samsung (R1-2002131) has the same view as Ericsson. More views are needed before making any decision on this issue. Companies are encouraged to provide their views on this.

***Proposal 3-4****: Further study whether to change the candidate RV values from {0, 3} to {0, 2} in case of 1 bit for Redundancy version for DCI format 0\_2.*

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| *Company* | *View* |
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**Issue A-5:** RRC Configuration for Cross-Carrier Scheduling

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| *Qualcomm R1-2002544*In the past RAN1 meetings, it was agreed that the size of the carrier indicator field (CIF) in the DCI format 0\_2 and 1\_2 can be configurable between 0 and 3 bits. In case the CIF has 1 or 2 bits, it is not clear how the UE determines the association between the index of a scheduled cell and a codepoint in the DCI. In Rel-15, this association is configured by the RRC parameter *cif-InSchedulingCell* under *CrossCarrierSchedulingConfig*. However, since this RRC parameter is configured targeting the DCI format 0\_1 and 1\_1, reusing this RRC parameter for DCI format 0\_2 and 1\_2 may not be appropriate. Therefore, we propose to introduce new RRC parameters to configure the scheduling cell index corresponding to DCI format 1\_2 and 0\_2, respectively. The proposed TP is provided below.

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| **Modified clause (Section 10.1 of 38.213)** |

If a UE is configured with *CrossCarrierSchedulingConfig* for a serving cell, the carrier indicator field value in DCI format 0\_1 and 1\_1 corresponds to the value indicated by *cif-InSchedulingCell* in *CrossCarrierSchedulingConfig,* the carrier indicator field value in DCI format 0\_2 and 1\_2 corresponds to the value indicated by *cif-InSchedulingCellForDCIFormat0\_2* and *cif-InSchedulingCellForDCIFormat1\_2, respectively****.***

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| **End** |

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**Issue A-6-1:** Correction to DMRS reception procedure for PDSCH scheduled by DCI formats 1\_2 (38.214, Sec. 5.1.3.2 & 5.1.6.2)

R1-2001694 bought up this issues, and propose to adopt the following TP for PDSCH DMRS reception with DCI format 1\_2 to Sec. 5.1.3.2 and 5.1.6.2 of TS 38.214 with changes marked in red, to address this issue by implementing the following logic:

* If *dmrs-DownlinkForPDSCH-MappingTypeA-ForDCIFormat1\_2* and *dmrs-DownlinkForPDSCH-MappingTypeB-ForDCIFormat1\_2* are not configured, the DMRS reception procedure for PDSCH scheduled by DCI format 1\_2 follows the fallback DCI operation (i.e. DCI format 1\_0)
* Otherwise (i.e. if configured), the intention of the current clause would apply here.

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| **TP to TS 38.214, DM-RS reception procedure affecting Sec. 5.1.3.2 and 5.1.6.2:**5.1.3.2 Transport block size determinationIn case the higher layer parameter *maxNrofCodeWordsScheduledByDCI* indicates that two codeword transmission is enabled, then one of the two transport blocks is disabled by DCI format 1\_1 if *IMCS* = 26 and if *rvid* = 1 for the corresponding transport block. If both transport blocks are enabled, transport block 1 and 2 are mapped to codeword 0 and 1 respectively. If only one transport block is enabled, then the enabled transport block is always mapped to the first codeword.For the PDSCH assigned by a PDCCH with DCI format 1\_0, format 1\_1 or format 1\_2 with CRC scrambled by C-RNTI, MCS-C-RNTI, TC-RNTI, CS-RNTI, or SI-RNTI, if Table 5.1.3.1-2 is used and $0 \leq I\_{MCS }\leq 27$*,* or a table other than Table 5.1.3.1-2 is usedand $0 \leq I\_{MCS }\leq 28$*,* the UE shall, except if the transport block is disabled in DCI format 1\_1, first determine the TBS as specified below:1) The UE shall first determine the number of REs (*NRE*) $N\_{RE})$within the slot. - A UE first determines the number of REs allocated for PDSCH within a PRB () by , where is the number of subcarriers in a physical resource block, $N\_{symb}^{slot}$ is the number of symbols of the PDSCH allocation within the slot, $N\_{DMRS}^{PRB}$ is the number of REs for DM-RS per PRB in the scheduled duration including the overhead of the DM-RS CDM groups without data, as indicated by DCI format 1\_1 or format 1\_2 or as described for format 1\_0 and format 1\_2 in Clause 5.1.6.2, and  $N\_{oh}^{PRB}$is the overhead configured by higher layer parameter *xOverhead* in *PDSCH-ServingCellConfig*. If the *xOverhead* in *PDSCH-ServingCellconfig* is not configured (a value from 0, 6, 12, or 18), the  is set to 0. If the PDSCH is scheduled by PDCCH with a CRC scrambled by SI-RNTI, RA-RNTI, MsgB-RNTI or P-RNTI,  is assumed to be 0.- A UE determines the total number of REs allocated for PDSCH ()$N\_{RE})$ by $N\_{RE}= \overbar{N}\_{RE}^{'}\* n\_{PRB}$, where *nPRB* is the total number of allocated PRBs for the UE. <Unchanged text is omitted>5.1.6.2 DM-RS reception procedureIf both higher layer parameter *dmrs-DownlinkForPDSCH-MappingTypeA-ForDCIFormat1\_2* and higher layer parameter *dmrs-DownlinkForPDSCH-MappingTypeB-ForDCIFormat1\_2* are notconfigured, the DM-RS reception procedures for PDSCH scheduled by PDCCH with DCI format 1\_0 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 1\_2; Otherwise, ~~T~~the DM-RS reception procedures for PDSCH scheduled by PDCCH with DCI format 1\_1 described in this clause~~section~~ equally apply to PDSCH scheduled by PDCCH with DCI format 1\_2, by applying the parameters of *dmrs-DownlinkForPDSCH-MappingTypeA-ForDCIFormat1\_2* and *dmrs-DownlinkForPDSCH-MappingTypeB-ForDCIFormat1\_2* instead of *dmrs-DownlinkForPDSCH-MappingTypeA* and *dmrs-DownlinkForPDSCH-MappingTypeB*.When receiving PDSCH scheduled by DCI format 1\_0 or receiving PDSCH before dedicated higher layer configuration of any of the parameters *dmrs-AdditionalPosition*, *maxLength* and *dmrs-Type,* the UE shall assume that the PDSCH is not present in any symbol carrying DM-RS except for PDSCH with allocation duration of 2 symbols with PDSCH mapping type B (described in clause 7.4.1.1.2 of [4, TS 38.211]), and a single symbol front-loaded DM-RS of configuration type 1 on DM-RS port 1000 is transmitted, and that all the remaining orthogonal antenna ports are not associated with transmission of PDSCH to another UE and in addition**<**Unchanged text is omitted> |

It seems the issue A-6-1 is valid, and we can discuss and endorse the corresponding TPs if time permit.

**Issue A-6-2:** Correction to DMRS transmission procedure for PUSCH scheduled by DCI format 0\_2 (38.214, Sec. 6.1.4.2 & 6.2.2)

Nokia (R1-2001694) bought up this issues, and propose to adopt the following text proposal for PUSCH DMRS transmission with DCI format 0\_2 to Sec. 6.1.4.2 and 6.2.2 of TS 38.214 with changes /additions marked in red, to address this issue by implementing the following logic:

* If *dmrs-UplinkForPUSCH-MappingTypeA-ForDCIFormat1\_2* and *dmrs-UplinkForPUSCH-MappingTypeB-ForDCIFormat1\_2* are not configured, the DMRS transmission procedure for PUSCH scheduled by DCI format 0\_2 follows the fallback DCI operation (i.e. DCI format 0\_0)
* Otherwise (i.e. if configured), the procedures of PUSCH scheduled by DCI format 0\_1 apply also for PUSCH scheduled by DCI format 0\_2 by using the separately configured DMRS parameters.

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| **TP to TS 38.214, Sec. 6.1.4.2 & 6.2.2: UE DM-RS transmission procedure description for DCI format 0\_2** 6.1.4.2 Transport block size determinationFor a PUSCH scheduled by RAR UL grant or for a PUSCH scheduled by fallbackRAR UL grant orfor a PUSCH scheduled by a DCI format 0\_0 with CRC scrambled by C-RNTI, MCS-C-RNTI, TC-RNTI, CS-RNTI, or for a PUSCH scheduled by a DCI format 0\_1 or DCI format 0\_2 with CRC scrambled by C-RNTI, MCS-C-RNTI, CS-RNTI, SP-CSI-RNTI, or for a PUSCH transmission with configured grant, orfor a MsgA PUSCH transmission,if- and transform precoding is disabled and Table 5.1.3.1-2 is used, or-  and transform precoding is disabled and a table other than Table 5.1.3.1-2 is used, or -  and transform precoding is enabled, the UE shall first determine the TBS as specified below:The UE shall first determine the number of REs (*NRE*) within the slot: - A UE first determines the number of REs allocated for PUSCH within a PRB  by - , where is the number of subcarriers in the frequency domain in a physical resource block,  $N\_{symb}^{slot}$is the number of symbols *L* of the PUSCH allocation according to Clause 6.1.2.1 for scheduled PUSCH of Clause 6.1.2.3 for configured PUSCH,  is the number of REs for DM-RS per PRB in the allocated duration including the overhead of the DM-RS CDM groups without data, as described for PUSCH with a configured grant in Clause 6.1.2.3 or as indicated by DCI format 0\_1 or DCI format 0\_2 or as described for DCI format 0\_0 and DCI format 0\_2 in Clause 6.2.2, and  is the overhead configured by higher layer parameter *xOverhead* in*PUSCH-ServingCellConfig*. If the  is not configured (a value from 6, 12, or 18), the  is assumed to be 0. For Msg3 transmission the  is always set to 0.**<**Unchanged text is omitted>6.2.2 UE DM-RS transmission procedureIf both higher layer parameter *dmrs-UplinkForPUSCH-MappingTypeA-ForDCIFormat0\_2* and higher layer parameter *dmrs-UplinkForPUSCH-MappingTypeB-ForDCIFormat0\_2* are notconfigured, the DM-RS transmission procedures for PUSCH scheduled by PDCCH with DCI format 0\_0 described in this clause equally apply to PUSCH scheduled by PDCCH with DCI format 0\_2; Otherwise, the DM-RS transmission procedures for PUSCH scheduled by PDCCH with DCI format 0\_1 described in this clause equally apply to PUSCH scheduled by PDCCH with DCI format 0\_2, by applying the parameters of *dmrs-UplinkForPUSCH-MappingTypeA-ForDCIFormat0\_2* and *dmrs-UplinkForPUSCH-MappingTypeB-ForDCIFormat0\_2* instead of *dmrs-UplinkForPUSCH-MappingTypeA* and *dmrs-UplinkForPUSCH-MappingTypeB*.When transmitted PUSCH is neither scheduled by DCI format 0\_1 with CRC scrambled by C-RNTI, CS-RNTI, SP-CSI-RNTI or MCS-C-RNTI, nor corresponding to a configured grant, nor being a PUSCH for Type-2 random access procedure,~~.~~ the UE shall use single symbol front-loaded DM-RS of configuration type 1 on DM-RS port 0 and the remaining REs not used for DM-RS in the symbols are not used for any PUSCH transmission except for PUSCH with allocation duration of 2 or less OFDM symbols with transform precoding disabled, additional DM-RS can be transmitted according to the scheduling type and the PUSCH duration as specified in Table 6.4.1.1.3-3 of [4, TS38.211] for frequency hopping disabled and as specified in Table 6.4.1.1.3-6 of [4, TS38.211] for frequency hopping enabled, and If frequency hopping is disabled:- The UE shall assume *dmrs-AdditionalPosition* equals to 'pos2' and up to two additional DM-RS can be transmitted according to PUSCH duration, orIf frequency hopping is enabled:- The UE shall assume *dmrs-AdditionalPosition* equals to 'pos1' and up to one additional DM-RS can be transmitted according to PUSCH duration.**<**Unchanged text is omitted> |

CATT (R1-2002082) also provides a TP to address the same issue:

### UE DM-RS transmission procedure

The DM-RS transmission procedures for PUSCH scheduled by PDCCH with DCI format 0\_1 described in this section equally apply to PUSCH scheduled by PDCCH with DCI format 0\_2, by applying the parameters of *dmrs-UplinkForPUSCH-MappingTypeA-ForDCI-Format0\_2* and *dmrs-UplinkForPUSCH-MappingTypeB-ForDCI-Format0\_2* instead of *dmrs-UplinkForPUSCH-MappingTypeA* and *dmrs-UplinkForPUSCH-MappingTypeB*.

When transmitted PUSCH is scheduled by DCI format 0\_0 or by RAR UL grant, the UE shall use single symbol front-loaded DM-RS of configuration type 1 on DM-RS port 0 and the remaining REs not used for DM-RS in the symbols are not used for any PUSCH transmission except for PUSCH with allocation duration of 2 or less OFDM symbols with transform precoding disabled, additional DM-RS can be transmitted according to the scheduling type and the PUSCH duration as specified in Table 6.4.1.1.3-3 of [4, TS38.211] for frequency hopping disabled and as specified in Table 6.4.1.1.3-6 of [4, TS38.211] for frequency hopping enabled, and

< -----------------------text omitted----------------------->

* and, the UE shall transmit a number of additional DM-RS as specified in Table 6.4.1.1.3-3 and Table 6.4.1.1.3-4 in -Clause 6.4.1.1.3 of [4, TS 38.211].

A UE may be scheduled with a number of DM-RS ports by the antenna port index in DCI format 0\_1 as described in Clause 7.3.1.1 of [5, TS 38.212].

If a UE transmitting PUSCH is configured with the higher layer parameter phaseTrackingRS in DMRS-UplinkConfig, the UE may assume that the following configurations are not occurring simultaneously for the transmitted PUSCH

< -----------------------text omitted----------------------->

It seems the issue A-6-2 is valid, and we can discuss and endorse the corresponding TPs if time permit.

**Issue A-7-1:** Missing PTRS transmission procedure for PUSCH scheduled by DCI format 0\_1 & 0\_2 (38.214 - Sec. 6.2.3 & 6.2.3.1, 38.212 – Sec. 7.3.1.1.2 & 7.3.1.1.3)

RAN1 had agreed to support independent PTRS configuration which is available due to the independent DMRS configurations for DCI format 0\_2 and Rel-15 containing the RRC parameter *phaseTrackingRS* in *DMRS-UplinkConfig*.

*Agreements:*

*Support new RRC configuration for “PTRS-DMRS association” in DCI format 0\_2*

Currently, the effect on PTRS is currently not at all addressed in Sec. 6.2.3 of TS 38.214. R1-2001694 proposes to adopt the following TP for PUSCH PTRS transmission with DCI format 0\_2 to Sec. 6.2.3 & 6.2.3.1 of TS 38.214 with changes marked in red:

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| **TP to TS 38.214, 6.2.3 and 6.2.3.1: UE PTRS transmission procedure description for DCI format 0\_2** 6.2.3 UE PT-RS transmission procedureThe procedures on PT-RS transmission described in this clause as well as clauses 6.2.3.1 and 6.2.3.2 apply to a UE PUSCH transmission scheduled by DCI format 0\_2 if the higher layer parameter *phaseTrackingRS* in *dmrs-UplinkForPUSCH-MappingTypeA-ForDCIFormat0\_2* or *dmrs-UplinkForPUSCH-MappingTypeB-ForDCIFormat0\_2* is configured, to PUSCH transmissions scheduled by DCI format 0\_0 or format 0\_1 if the higher layer parameter *phaseTrackingRS* in *dmrs-UplinkForPUSCH-MappingTypeA* or *dmrs-UplinkForPUSCH-MappingTypeB* is configured and PUSCH transmissions corresponding to a configured grant if the higher layer parameter *phaseTrackingRS* in *cg-DMRS-Configuration* is configured. If a UE is not configured with the higher layer parameter *phaseTrackingRS* inthe respective *DMRS-UplinkConfig*, the UE shall not transmit PT-RS. ThePTRS is only present on PUSCH scheduled by PDCCH with CRC scrambled by MCS-C-RNTI, C-RNTI, CS-RNTI, SP-CSI-RNTI and on PUSCH corresponding to a configured grant. For PUSCH repetition Type B, the PT-RS transmission procedure is applied for each actual repetition separately based on the allocation duration of the actual repetition.6.2.3.1 UE PT-RS transmission procedure when transform precoding is not enabled**<**Unchanged text is omitted>For codebook or non-codebook based UL transmission, the association between UL PT-RS port(s) and DM-RS port(s) is signalled by *PTRS-DMRS association* field in DCI format 0\_1 and DCI format 0\_2. For a PUSCH corresponding to a configured grant Type 1 transmission, the UE may assume the association between UL PT-RS port(s) and DM-RS port(s) defined by value 0 in Table 7.3.1.1.2-25 or value "00" in Table 7.3.1.1.1.2-26 described in Clause 7.3.1 of [5, TS38.212].For PUSCH scheduled by DCI format 0\_0 or by activation DCI format 0\_0, the UL PT-RS port is associated to DM-RS port 0.For non-codebook based UL transmission, the actual number of UL PT-RS port(s) to transmit is determined based on SRI(s) in DCI format 0\_1 and DCI format 0\_2 or higher layer parameter *sri-ResourceIndicator* in *rrc-ConfiguredUplinkGrant*. A UE is configured with the PT-RS port index for each configured SRS resource by the higher layer parameter *ptrs-PortIndex* configured by *SRS-Config* if the UE is configured with the higher layer parameter *phaseTrackingRS in DMRS-UplinkConfig*. If the PT-RS port index associated with different SRIs are the same, the corresponding UL DM-RS ports are associated to the one UL PT-RS port.For partial-coherent and non-coherent codebook based UL transmission, the actual number of UL PT-RS port(s) is determined based on TPMI and/or number of layers which are indicated by *Precoding information and number of layers* field in DCI format 0\_1 and DCI format 0\_2 or configured by higher layer parameter *precodingAndNnumberOfLayers*:- if the UE is configured with the higher layer parameter *maxNrofPorts* in *PTRS-UplinkConfig* set to 'n2', the actual UL PT-RS port(s) and the associated transmission layer(s) are derived from indicated TPMI as:- PUSCH antenna port 1000 and 1002 in indicated TPMI share PT-RS port 0, and PUSCH antenna port 1001 and 1003 in indicated TPMI share PT-RS port 1.- UL PT-RS port 0 is associated with the UL layer [x] of layers which are transmitted with PUSCH antenna port 1000 and PUSCH antenna port 1002 in indicated TPMI, and UL PT-RS port 1 is associated with the UL layer [y] of layers which are transmitted with PUSCH antenna port 1001 and PUSCH antenna port 1003 in indicated TPMI, where [x] and/or [y] are given by DCI parameter *PTRS-DMRS association* as shown in DCI format 0\_1 and DCI format 0\_2 described in Clause 7.3.1 of [5, TS38.212].**<**Unchanged text is omitted> |

Similarly, Nokia proposes to adopt the following text proposal on the PTRS-DMRS association field for DCI format 0\_1 and 0\_2 to Sec. 7.3.1.1.2 & 7.3.1.1.3 of TS 38.212 with changes marked in red:

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| **TP to TS 38.212, 7.3.1.1.2 and 7.3.1.1.3: Correction to DCI field size determination for PTRS-DMRS association**7.3.1.1.2 Format 0\_1**<**Unchanged text is omitted>- PTRS-DMRS association – number of bits determined as follows- 0 bit if *PTRS-UplinkConfi*g in *dmrs-UplinkForPUSCH-MappingTypeA* or *dmrs-UplinkForPUSCH-MappingTypeB* is not configured and transform precoder is disabled, or if transform precoder is enabled, or if *maxRank=1*;- 2 bits otherwise, where Table 7.3.1.1.2-25 and 7.3.1.1.2-26 are used to indicate the association between PTRS port(s) and DMRS port(s) for transmission of one PT-RS port and two PT-RS ports respectively, and the DMRS ports are indicated by the Antenna ports field. If "Bandwidth part indicator" field indicates a bandwidth part other than the active bandwidth part and the "PTRS-DMRS association" field is present for the indicated bandwidth part but not present for the active bandwidth part, the UE assumes the "PTRS-DMRS association" field is not present for the indicated bandwidth part.**<**Unchanged text is omitted>7.3.1.1.3 Format 0\_2**<**Unchanged text is omitted>- PTRS-DMRS association – number of bits determined as follows- 0 bit if *PTRS-UplinkConfi*g in *dmrs-UplinkForPUSCH-MappingTypeA-ForDCIFormat0\_2* or *dmrs-UplinkForPUSCH-MappingTypeB-ForDCIFormat0\_2* is not configured and transform precoder is disabled, or if transform precoder is enabled, or if *maxRank-ForDCIFormat0\_2=1*;- 2 bits otherwise, where Table 7.3.1.1.2-25 and 7.3.1.1.2-26 are used to indicate the association between PTRS port(s) and DMRS port(s) for transmission of one PT-RS port and two PT-RS ports respectively, and the DMRS ports are indicated by the Antenna ports field. If "Bandwidth part indicator" field indicates a bandwidth part other than the active bandwidth part and the "PTRS-DMRS association" field is present for the indicated bandwidth part but not present for the active bandwidth part, the UE assumes the "PTRS-DMRS association" field is not present for the indicated bandwidth part.**<**Unchanged text is omitted> |

It seems the issue A-7-1 is valid, and we can discuss and endorse the corresponding TPs if time permit.

**Issue A-7-2:** Missing PTRS reception procedure for PDSCH scheduled by DCI formats 1\_2 (38.214, Sec. 5.1.6.2 & 5.1.6.3)

RAN1 had agreed to support independent PTRS configuration which is available due to the independent DMRS configurations for DCI format 1\_2 and Rel-15 containing the RRC parameter *phaseTrackingRS* in *DMRS-DownlinkConfig*. Currently, the effect on PTRS is currently not at all addressed in Sec. 5.1.6.2 and Sec. 5.1.6.3 of TS 38.214. R1-2001694 proposes to adopt the following text proposal for PDSCH PTRS reception with DCI format 1\_2 to Sec. 5.1.6.2 & 5.1.6.3 of TS 38.214 with changes marked in red:

|  |
| --- |
| **TP to TS 38.214, 5.1.6.2 & 5.1.6.3: UE PTRS reception procedure description for DCI format 1\_2** 5.1.6.2 DM-RS reception procedure**<**Unchanged text is omitted>If a UE receiving PDSCH scheduled by DCI format 1\_2 is configured with the higher layer parameter *phaseTrackingRS* in *dmrs-DownlinkForPDSCH-MappingTypeA-ForDCIFormat1\_2* or *dmrs-DownlinkForPDSCH-MappingTypeB-ForDCIFormat1\_2* or a UE receiving PDSCH scheduled by DCI format 1\_0 or DCI format 1\_1 is configured with the higher layer parameter *phaseTrackingRS* in *dmrs-DownlinkForPDSCH-MappingTypeA* or *dmrs-DownlinkForPDSCH-MappingTypeB ~~DMRS-DownlinkConfig~~*, the UE may assume that the following configurations are not occurring simultaneously for the received PDSCH:- any DM-RS ports among 1004-1007 or 1006-1011 for DM-RS configurations type 1 and type 2, respectively are scheduled for the UE and the other UE(s) sharing the DM-RS REs on the same CDM group(s), and- PT-RS is transmitted to the UE.**<**Unchanged text is omitted>5.1.6.3 PT-RS reception procedureThe procedures on PT-RS reception described in this clause apply to a UE receiving PDSCH scheduled by DCI format 1\_2 configured with the higher layer parameter *phaseTrackingRS* in *dmrs-DownlinkForPDSCH-MappingTypeA-ForDCIFormat1\_2* or *dmrs-DownlinkForPDSCH-MappingTypeB-ForDCIFormat1\_2* and to a UE receiving PDSCH scheduled by DCI format 1\_0 or format 1\_1 configured with the higher layer parameter *phaseTrackingRS* in *dmrs-DownlinkForPDSCH-MappingTypeA* or *dmrs-DownlinkForPDSCH-MappingTypeB*. A UE shall report the preferred MCS and bandwidth thresholds based on the UE capability at a given carrier frequency, for each subcarrier spacing applicable to data channel at this carrier frequency, assuming the MCS table with the maximum Modulation Order as it reported to support.**<**Unchanged text is omitted> |

It seems the issue A-7-2 is valid, and we can discuss and endorse the corresponding TPs if time permit.

**Issue A-8:** Correction to FH field size definition for DCI format 0\_2 (38.212, Sec. 7.3.1.1.3)

R1-2001694 proposes to correct the FH flag field size definition for DCI format 0\_2 to clarify the operation if configured with resource allocation type 0 in Sec. 7.3.1.1.3 of TS 38.212 by agreeing to the following TP with changes in red:

|  |
| --- |
| **TP to TS 38.212, 7.3.1.1.3 to correct the FH bit field size & usage for DCI format 0\_2**7.3.1.1.3 Format 0\_2**<**Unchanged text is omitted>- Frequency hopping flag – 0 or 1 bit:- 0 bit if only resource allocation type 0 is configured or if the higher layer parameter *frequencyHopping-ForDCIFormat0\_2* is not configured;- 1 bit according to Table 7.3.1.1.1-3 otherwise, only applicable to resource allocation type 1, as defined in Clause 6.3 of [6, TS 38.214].**<**Unchanged text is omitted> |

From feature lead perspective, even without this clarification the current spec is right, since anyway when only resource allocation type 0 is configured the higher layer parameter *frequencyHopping-ForDCIFormat0\_2* won’t be configured, and it seems from 38.214 Clause 6.3 it is clear that frequency hopping is only applied to resource allocation type 1, but seems no harm to align with DCI format 0\_1. If time permit, we can consider to discuss this TP.

**Issue A-9:** Correction to PDSCH TDRA for DCI formats 1\_2 (38.214, Sec. 5.1.2.1)

When implementing the URLLC CR in Dec. 2019, there has been a small mistake in the editing which now looks as if the TDRA length L is only available if the new reference SLIV is not configured (i.e. for the otherwise clause). We mark this issue in yellow below from the current specifications:

|  |
| --- |
| - The reference point *S0* for starting symbol *S* is defined as: - if configured with *ReferenceofSLIV-ForDCIFormat1\_2*, and when receiving PDSCH scheduled by DCI format 1\_2 with CRC scrambled by C-RNTI, MCS-C-RNTI, CS-RNTI with *K0=0*, and PDSCH mapping Type B, the starting symbol *S* is relative to the starting symbol *S0* of the PDCCH monitoring occasion where DCI format 1\_2 is detected; - otherwise, the starting symbol *S* is relative to the start of the slot using *S0=0*, and the starting symbol *S* relative to the start of the slot, and the number of consecutive symbols *L* counting from the symbol *S* allocated for the PDSCH are determined from the start and length indicator *SLIV*:if  thenelse where, and- the PDSCH mapping type is set to Type A or Type B as defined in Clause 7.4.1.1.2 of [4, TS 38.211]. |

This is clearly an error and should be corrected (please note, that there is now separate new bullet re-added from the CR – so that the length L applies to both if conditions on the reference SLIV!). R1-2001694 proposes to adopt the following text proposal /correct to the time domain resource allocation for DCI format 1\_2 to Sec. 5.1.2.1 of TS 38.214 with the changes in red:

|  |
| --- |
| **TP to TS 38.214, Sec. 5.1.2.1 – needed correction to TDRA definition (due to error in the URLLC CR implementation)**5.1.2.1 Resource allocation in time domainWhen the UE is scheduled to receive PDSCH by a DCI, the *Time domain resource assignment* field value *m* of the DCI provides a row index *m* + 1 to an allocation table. The determination of the used resource allocation table is defined in Clause 5.1.2.1.1. The indexed row defines the slot offset *K0*, the start and length indicator *SLIV*, or directly the start symbol *S* and the allocation length *L*, and the PDSCH mapping type to be assumed in the PDSCH reception.Given the parameter values of the indexed row:- The slot allocated for the PDSCH is *Ks*, where , if UE is configured with *CA-slot-offset* for at least one of the scheduled and scheduling cell, and *Ks* = , otherwise, and where *n* is the slot with the scheduling DCI, and *K0* is based on the numerology of PDSCH, and  and are the subcarrier spacing configurations for PDSCH and PDCCH, respectively, and- $N\_{slot, offset, PDCCH}^{CA}$ and $μ\_{offset,PDCCH}$ are the $N\_{slot, offset}^{CA}$ and the, respectively, which are determined by higher-layer configured *CA-slot-offset*, for the cell receiving the PDCCH respectively,$ N\_{slot, offset, PDSCH}^{CA}$ and $μ\_{offset,PDSCH}$ are the $N\_{slot, offset}^{CA}$ and the, respectively, which are determined by higher-layer configured CA-slot-offset for the cell receiving the PDSCH, as defined in clause 4.5 of [4, TS 38.211].- The reference point *S0* for starting symbol *S* is defined as: - if configured with *ReferenceofSLIV-ForDCIFormat1\_2*, and when receiving PDSCH scheduled by DCI format 1\_2 with CRC scrambled by C-RNTI, MCS-C-RNTI, CS-RNTI with *K0=0*, and PDSCH mapping Type B, the starting symbol *S* is relative to the starting symbol *S0* of the PDCCH monitoring occasion where DCI format 1\_2 is detected; - otherwise, the starting symbol *S* is relative to the start of the slot using *S0=0*.~~, and the starting symbol~~ *~~S~~* ~~relative to the start of the slot, and~~ - T~~t~~he number of consecutive symbols *L* counting from the starting symbol *S* allocated for the PDSCH are determined from the start and length indicator *SLIV*:if  thenelse where, and- the PDSCH mapping type is set to Type A or Type B as defined in Clause 7.4.1.1.2 of [4, TS 38.211].**<**Unchanged text is omitted> |

**Issue A-10:** Remove CBG PUSCH additions to DCI format 0\_1 (38.212, Sec. 7.3.1.1.2)

R1- 2001694 (Nokia) and R1-2002391 (Sharp) proposes to remove the addition of CBG based PUSCH additions to DCI format 0\_1 in Sec. 7.3.1.1.2 of TS 38.212 by agreeing to the following TP with changes in red:

|  |
| --- |
| **TP to TS 38.212, 7.3.1.1.2: Removal of CBGTI size alignment clause for DCI format 0\_1**7.3.1.1.2 Format 0\_1**<**Unchanged text is omitted>- CSI request – 0, 1, 2, 3, 4, 5, or 6 bits determined by higher layer parameter *reportTriggerSize*.- CBG transmission information (CBGTI) – 0 bit if higher layer parameter *codeBlockGroupTransmission* for PUSCH is not configured or if the number of scheduled PUSCH indicated by the Time domain resource assignment field is larger than 1; otherwise, 2, 4, 6, or 8 bits determined by higher layer parameter *maxCodeBlockGroupsPerTransportBlock* for PUSCH. ~~[When two HARQ-ACK codebooks are configured for the same serving cell, if the bit width of the CBG transmission information in DCI format 0\_1 for one HARQ-ACK codebook is not equal to that of the CBG transmission information in DCI format 0\_1 for the other HARQ-ACK codebook, a number of most significant bits with value set to '0' are inserted to smaller CBG transmission information until the bit width of the CBG transmission information in DCI format 0\_1 for the two HARQ-ACK codebooks are the same.]~~- PTRS-DMRS association – number of bits determined as follows**<**Unchanged text is omitted> |

The reasons given in R1-2001694 are as below:

* The CBG PUSCH operation has nothing to do with the operation of two PDSCH HARQ-Ack codebooks.
* RAN1 did not agree to support separate CBG operation for PUSCH with respect to different PUSCH priorities (which somehow would be corresponding to different HARQ-Ack codebooks for PDSCH).
* It does no really make sense to configure separately, as the DCI overhead would be given by the larger size of the CBGTI field for DCI format 0\_1 – therefore, no advantage of allowing such separate configuration is identified which is very much in contrast to CBG of PDSCH for the two HARQ-Ack codebooks resulting in different codebook sizes.

The related working assumptions and agreements are copied below for convenience:

|  |
| --- |
| Working assumption:When the UE is configured with two HARQ-ACK codebooks at least for the case when only one of the two DCI formats (1\_1 and 1\_2 for DL, 0\_1 and 0\_2 for UL), configured to support two HARQ-ACK codebooks, is configured to be monitored by the UE, the bit width of the following fields is the maximum of the bit widths for the two configurations corresponding to the two HARQ-ACK codebooks. The necessary number of most significant zero bits can be added to a field to achieve the alignment. * PDSCH-to-HARQ\_feedback timing indicator
* Beta offset indicator
* DAI
* CBGTI & CBGFI (if configured for the low priority HARQ-ACK codebook for DCI format 1\_1 and DCI format 0\_1)

Agreements:When at least two HARQ-ACK codebooks are simultaneously constructed for supporting different service types for a UE, at least the followings are separately configured.* *For DG*
	+ *UCI-OnPUSCH*
* *For CG*
	+ *FFS*
* *codeBlockGroupTransmission*
* *FFS K1*
 |

It seems the agreements are not that clear. We can discuss this issues if time permits. This issue is related to issues A-3.

**Issue A-11:** Pi/2-BPSK for the new DMRS and DCI format 0\_2

|  |  |
| --- | --- |
| *Qualcomm R1-2002544*A low PAPR DMRS for uplink transmissions with transform precoding and pi/2-BPSK modulation is added in eMIMO WI of Rel. 16 and can be used via DCI format 0\_1. The same functionality should also be enabled using DCI format 0\_2 which is more for URLLC scheduling; in such a case, low PAPR transmission would help enhancing uplink coverage and enhancing reliability.

|  |
| --- |
| **Modified clause (Section 7.3.1.1.3 of 38.212)** |

- Antenna ports – number of bits determined by the following:- 0 bit if higher layer parameter *AntennaPorts-FieldPresence-ForDCIFormat0\_2* is notconfigured;- 2, 3, 4, or 5 bits otherwise,- 2 bits as defined by Tables 7.3.1.1.2-6, if transform precoder is enabled, *dmrs-Type*=1, and *maxLength*=1 except that *DMRSuplinkTransformPrecoding-r16* and *tp-pi2BPSK* are both configured and π/2 BPSK modulation is used;- 2 bits as defined by Tables 7.3.1.1.2-6A, if transform precoder is enabled and *DMRSuplinkTransformPrecoding-r16* and *tp-pi2BPSK* are both configured, π/2 BPSK modulation is used, *dmrs-Type*=1, and *maxLength*=1, where nSCID is the scrambling identity for antenna ports defined in [Clause 6.4.1.1.1, TS38.211];- 4 bits as defined by Tables 7.3.1.1.2-7, if transform precoder is enabled, *dmrs-Type*=1, and *maxLength*=2 except that *DMRSuplinkTransformPrecoding-r16* and *tp-pi2BPSK* are both configured and π/2 BPSK modulation is used;- 4 bits as defined by Tables 7.3.1.1.2-7A, if transform precoder is enabled and *DMRSuplinkTransformPrecoding-r16* and *tp-pi2BPSK* are both configured, π/2 BPSK modulation is used, *dmrs-Type*=1, and *maxLength*=2, where nSCID is the scrambling identity for antenna ports defined in [Clause 6.4.1.1.1, TS38.211];- 3 bits as defined by Tables 7.3.1.1.2-8/9/10/11, if transform precoder is disabled, *dmrs-Type*=1, and *maxLength*=1, and the value of rank is determined according to the SRS resource indicator field if the higher layer parameter *txConfig = nonCodebook* and according to the Precoding information and number of layers field if the higher layer parameter *txConfig = codebook*;- 4 bits as defined by Tables 7.3.1.1.2-12/13/14/15, if transform precoder is disabled, *dmrs-Type*=1, and *maxLength*=2, and the value of rank is determined according to the SRS resource indicator field if the higher layer parameter *txConfig = nonCodebook* and according to the Precoding information and number of layers field if the higher layer parameter *txConfig = codebook*;- 4 bits as defined by Tables 7.3.1.1.2-16/17/18/19, if transform precoder is disabled, *dmrs-Type*=2, and *maxLength*=1, and the value of rank is determined according to the SRS resource indicator field if the higher layer parameter *txConfig = nonCodebook* and according to the Precoding information and number of layers field if the higher layer parameter *txConfig = codebook*;- 5 bits as defined by Tables 7.3.1.1.2-20/21/22/23, if transform precoder is disabled, *dmrs-Type*=2, and *maxLength*=2, and the value of rank is determined according to the SRS resource indicator field if the higher layer parameter *txConfig = nonCodebook* and according to the Precoding information and number of layers field if the higher layer parameter *txConfig = codebook*. |

**Issue A-12:** PUCCH resource determination for reduced size of PRI field

|  |
| --- |
| *Spreadtrum R1-2002255*PRI field in DCI format 1\_2 can be configured as 0/1/2/3 bits. - PUCCH resource indicator – 0 or 1 or 2 or 3 bits determined by higher layer parameter *Numberofbits-forPUCCHresourceindicator-ForDCIFormat1\_2*One open issue is how to determine the PUCCH resource when it is without PRI. This issue raised by many contributions and two options can be for further study.Option 1: defined as the first PUCCH resource configured in the setOption 2: using a first CCE index to determine the PUCCH resourceClearly, Option 1 is the easier solution and also used for bit width of PRI field is 1 or 2 bits, as well as other fields in DCI format 0\_2/1\_2 which bit widths are less than corresponding fields in DCI 0\_1/1\_1. 1. ***PUCCH resources corresponding to a PUCCH resource allocation field with 0 bits are the first configured PUCCH resources.***
 |

The issue is valid, if time permits we can discuss.

**Issue A-13:** Missing case of PUSCH release for search space sharing

Sharp (R1-2002391) proposes to adopt the following TP2 for section 10.1 in TS 38.213 to compensate for a missing case of PUSCH release for search space sharing.

|  |
| --- |
| **TP2**TS 38.213 V16.1.0 (2020-03)10.1 UE procedure for determining physical downlink control channel assignment< Unchanged parts are omitted >A UE that - is configured for operation with carrier aggregation, and - indicates support of search space sharing through *searchSpaceSharingCA-UL* or through *searchSpaceSharingCA-DL*, and - has a PDCCH candidate with CCE aggregation level  in CORESET  for a first DCI format scheduling PUSCH transmission or releasing PUSCH transmission, other than DCI format 0\_0, or for a second DCI format scheduling PDSCH reception or SPS PDSCH release, other than DCI format 1\_0, having a first size and associated with serving cell , can receive a corresponding PDCCH through a PDCCH candidate with CCE aggregation level  in CORESET  for a first DCI format or for a second DCI format, respectively, having a second size and associated with serving cell  if the first size and the second size are same.< Unchanged parts are omitted > |

**Issue A-14:** Correction on Transmission configuration indication in DCI format 1\_2

ASUSTeK (R1-2002484) proposes to adopt the following TP to enable same size of TCI bitfield as current CORESET for all CORESETs in target BWP for a BWP switching DCI similar as in Rel-15.

|  |
| --- |
| Transmission configuration indication – 0 bit if higher layer parameter *tci-PresentInDCI-ForDCIFormat1\_2* is not configured; otherwise 1 or 2 or 3 bits determined by higher layer parameter *tci-PresentInDCI-ForDCIFormat1\_2* as defined in Subclause 5.1.5 of [6, TS38.214]. If "Bandwidth part indicator" field indicates a bandwidth part other than the active bandwidth part, - if the higher layer parameter *tci-PresentInDCI-ForDCIFormat1\_2* is not configured for the CORESET used for the PDCCH carrying the DCI format 1\_2,- the UE assumes *tci-PresentInDCI-ForDCIFormat1\_2* is not configured for all CORESETs in the indicated bandwidth part;- otherwise,- the UE assumes *tci-PresentInDCI-ForDCIFormat1\_2* for all CORESETs in the indicated bandwidth part is configured and with same value as the higher layer parameter *tci-PresentInDCI-ForDCIFormat1\_2* for the CORESET used for the PDCCH carrying the DCI format 1\_2. |

***Miscellaneous corrections***

**Issue A-15-1:** Correction on UL-SCH indicator field for DCI format 0\_2 (38.212, Sec. 7.3.1.1.3)

In the current field description, there is still the exception of CS-RNTI in brackets which is directly taken from the Rel-15 exception of DCI format 0\_1. R1-2001694 proposes to remove the brackets in the UL-SCH indicator field description of DCI format 0\_2 in Sec. 7.3.1.1.3 of TS 38.212 by agreeing to the following TP with changes in red:

|  |
| --- |
| **TP to TS 38.212, 7.3.1.1.3 on UL-SCH indicator for DCI format 0\_2**7.3.1.1.3 Format 0\_2**<**Unchanged text is omitted>- UL-SCH indicator – 1 bit. A value of "1" indicates UL-SCH shall be transmitted on the PUSCH and a value of "0" indicates UL-SCH shall not be transmitted on the PUSCH. ~~[~~Except for DCI format 0\_2 with CRC scrambled by SP-CSI-RNTI,~~]~~ a UE is not expected to receive a DCI format 0\_2 with UL-SCH indicator of "0" and CSI request of all zero(s).**<**Unchanged text is omitted> |

From feature lead perspective, the issue is valid and it belongs editorial changes. If time permits, we can discuss and correct it.

**Issue A-15-2:** Typo/Remove underline from new RRC parameter in UE PDCCH procedures (38.213, Sec. 10.1)

R1-2001694 proposes to adopt the following change to Sec. 10.1 of TS 38.213 to remove the underline from the text marked in yellow:

|  |
| --- |
| **TP to TS 38.213, 10.1 – editorial change (removal of underline)**10.1 UE procedure for determining physical downlink control channel assignment **<**Unchanged text is omitted>- an indication for a presence or absence of a transmission configuration indication (TCI) field for a DCI format, other than DCI format 1\_0, that schedules PDSCH receptions or indicates SPS PDSCH release and is transmitted by a PDCCH in CORESET , by *tci-PresentInDCI* or tci-PresentInDCI-ForDCIFormat1\_2.**<**Unchanged text is omitted> |

From feature lead perspective, the issue is valid and it belongs editorial changes. If time permits, we can discuss and correct it.

**Issue A-10-3:** Typo in Modulation order for PUSCH (38.214, Sec. 6.1.4.1)

R1-2001694 proposes to adopt the following text proposal for PUSCH modulation order to Sec. 6.1.4.1. to correct a typo marked in red:

|  |
| --- |
| **TP to TS 38.214, 6.1.4.1: fix a typo in PUSCH modulation order description**6.1.4.1 Modulation order and target code rate determinationFor a PUSCH scheduled by RAR UL grant or for a PUSCH scheduled by a fallbackRAR UL grant orfor a MsgA PUSCH transmission, orfor a PUSCH scheduled by a DCI format 0\_0 with CRC scrambled by C-RNTI, MCS-C-RNTI, TC-RNTI, CS-RNTI, or for a PUSCH scheduled by a DCI format 0\_1 ~~f~~or DCI format 0\_2 with CRC scrambled by C-RNTI, MCS-C-RNTI, CS-RNTI, SP-CSI-RNTI, or for a PUSCH with configured grant using CS-RNTI, and**<**Unchanged text is omitted> |

**Issue A-10-4:** Text proposals to align the RRC parameter names between TS 38.331 and TS 38.212

CATT (R1-2002082) provides a set of TPs to align the RRC parameter names between TS 38.331 and TS 38.212, which a valid issue. It is some editorial changes. If time permits, we can discuss and correct it, otherwise we can leave it to editor or future meetings.

Some other issues are raised in OPPO R1 R1-2001773 and Spreadtrum R1-2002255. Due to the time limit, probably we can delay it to next meeting.

# Enhanced PDCCH monitoring capability

This section summarize the issues on enhanced PDCCH monitoring capability.

## Values for C and M for enhanced PDCCH monitoring capability

**Issue B-1:** The per-CC limit on the maximum number of non-overlapping CCEs per monitoring span for (2, 2) and (4, 3)

No agreement has been achieved so far on the number of non-overlapping CCEs for span patterns (2, 2) and (4, 3) for the SCS 15 kHz and 30 kHz. This issue has been extensively discussed during the work item but companies have not been able to converge.

Currently, the maximum numbers of non-overlapping CCEs are captured as follows in the specification.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 10.1-3A: Maximum number $C\_{PDCCH}^{max,\left(X,Y\right),μ}$ of non-overlapped CCEs in a span of a span pattern (X, Y) for a DL BWP with SCS configuration $μ\in \left\{0, 1\right\}$ for a single serving cell

|  |  |
| --- | --- |
|  | Maximum number $C\_{PDCCH}^{max,\left(X,Y\right),μ}$ of non-overlapped CCEs per span pattern $\left(X,Y\right)$ and per serving cell  |
| $$μ$$ | (2, 2) | (4, 3) | (7, 3) |
| 0 | C01 | C02 | 56 |
| 1 | C11 | C12 | 56 |

 |

The views from companies are summarized as below:

|  |  |  |
| --- | --- | --- |
| Company | 15 kHz SCS | 30 kHz SCS |
| (2, 2) | (4, 3) | (2, 2) | (4, 3) |
| Ericsson  | 32 | 48 | 32 | 48 |
| vivo  | 24 | 48 | 24 | 48 |
| Nokia  | 32 | 48 | 32 | 48 |
| MTK  | 24 | 48 | 24 | 48 |
| OPPO | - | - | 16 | 32 |
| CATT  | 24 | 32 | 24 | 32 |
| Samsung  | 48 | 56 | 48 | 56 |
| Intel | 20 | 40 | 20 | 38 |
| Apple  | 18 | 32 | 18 | 32 |
| Spreadtrum  | 16 | 32 | 16 | 32 |
| NTT DCM  | 32 | 56 | 32 | 32 |
| Qualcomm | 16 | 36 | 16 | 36 |
| Huawei/HiSi  | 28 | 36 | 28 | 36 |
| ZTE | 16 | 36 | 16 | 36 |
| Panasonic | 18 | 32 | 18 | 32 |

The issues was discussed extensively and unfortunately no consensus was achieved. Based on the views in the contributions, it seems same situation is still there. On the one hand, UE vendors cannot provide a higher number due to UE complexity, on the other hand network vendors prefer a larger value and prefer less UE capabilities. In RAN1#99 meeting, we were discussing to take 18 for (2, 2) and 32 for (4, 3) (i.e. option 1 below) as working assumption as shown in R1-1913541, however no consensus was achieved due to the strong concern from a few companies. Another one possible way is to take multiple values for each combination and let UE report it as UE capability, however it seems some companies don’t like this way either. Let’s take these two options as the starting point for discussion, companies are encouraged to provide your preference.

***Proposal 4.1-1****: For limit C on the maximum number of non-overlapping CCEs for channel estimation per PDCCH monitoring span,*

* ***Option 1****：*
	+ *The value of C for combination (4, 3) for 15 kHz and 30 kHz is 32.*
	+ *The value of C for combination (2, 2) for 15 kHz and 30 kHz is 18.*
* ***Option 2****：*
	+ *For the value of C for combination (4, 3) for 15 kHz and 30 kHz, UE can report one of following values as a UE capability:*
		- *32*
		- *48*
	+ *For the value of C for combination (2, 2) for 15 kHz and 30 kHz, UE can report one of following values as a UE capability:*
		- *16*
		- *32*

**Companies are encouraged to provide your views and your reasons**. If you have strong objection on the framework of either option 1 or option 2, please indicate here also. Considering we have to solve this issue by email discussions, please all of you to be constructive also.

|  |  |
| --- | --- |
| *Company* | *View* |
|  |  |
|  |  |

**Issue B-2:** The per-CC limit on the maximum number of monitored PDCCH candidates per monitoring span

No agreement has been achieved on the number of blind decodes for (2, 2), (4, 3) and (7, 3) for the SCS 15 kHz and 30 kHz, nor on the number of supported carriers. Although an enhancement of the number of BDs is not explicitly in the scope of the WID [1], these issues have been extensively discussed during the work item but companies have not been able to converge.

The maximum numbers of monitored PDCCH candidates per span are captured as follows in the specification:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 10.1-2A: Maximum number $M\_{PDCCH}^{max,\left(X,Y\right),μ}$ of monitored PDCCH candidates in a span of a span pattern (X, Y) for a DL BWP with SCS configuration $μ\in \left\{0, 1\right\}$ for a single serving cell

|  |  |
| --- | --- |
|  | Maximum number $M\_{PDCCH}^{max,\left(X,Y\right),μ}$ of monitored PDCCH candidates per span pattern $\left(X,Y\right)$ and per serving cell  |
| $$μ$$ | (2, 2) | (4, 3) | (7, 3) |
| 0 | M01 | M02 | M03 |
| 1 | M11 | M12 | M13 |

 |

The views from companies are summarized as below:

|  |  |  |
| --- | --- | --- |
| Company | 15 kHz SCS | 30 kHz SCS |
|  | (2,2) | (4,3) | (7,3) | (2,2) | (4,3) | (7,3) |
| Ericsson  | 28 | 32 | 44 | 24 | 28 | 36 |
| Vivo  | 18 | 36 | 44 | 14 | 28 | 36 |
| Nokia  | 20 | 30 | 44 | 16 | 24 | 36 |
| MTK  | 14 | 30 | 44 | 12 | 24 | 36 |
| OPPO  | - | - | - | 10 | 24 | 36 |
| Samsung  | 12 | 28 | 44 | 10 | 24 | 36 |
| Intel  | 14 | 24 | 44 | 12 | 20 | 36 |
| Apple  | 12 | 30 | 44 | 10 | 24 | 36 |
| Spreadtrum  | 10 | 24 | 36 | 8 | 18 | 28 |
| NTT DCM  | 12 | 30 | 44 | 10 | 24 | 36 |
| Qualcomm  | 12 | 28 | 44 | 10 | 24 | 36 |
| HW/HiSi  | 8 | 18 | 28 | 8 | 18 | 28 |
| ZTE | 12 | 28 | 44 | 10 | 24 | 36 |
| CATT | 12 | 22 | 44 | 10 | 16 | 36 |
| Panasonic  | 12 | 28 | 44 | 10 | 24 | 36 |

Unfortunately the views are very diverse. Similar as the capability for CCE, the following proposal are given as the starting point for discussion. Note that the values got the most support are given in option 1 in the following proposal. For option 2, really difficult for what value to pick, some medium values are chosen here. And to reduce the potential UE capability, probably we can discuss whether any chance to have same candidate values for 15 kHz and 30 kHz.

***Proposal 4.1-2****: For limit M on the maximum number of monitored PDCCH candidates per monitoring span,*

* ***Option 1****：*
	+ *For 15 kHz,*
		- *The value of M03 for combination (7, 3) is 44*
		- *The value of M02 for combination (4, 3) is 28*
		- *The value of M01 for combination (2, 2) is 12*
	+ *For 30 kHz,*
		- *The value of M13 for combination (7, 3) is 36*
		- *The value of M12 for combination (4, 3) is 24*
		- *The value of M11 for combination (2, 2) is 10*
* ***Option 2****：*
	+ *For 15 kHz,*
		- *UE can report one of following values for combination (7, 3) as a UE capability:*
			* *44*
			* *28*
		- *UE can report one of following values for combination (4, 3) as a UE capability:*
			* *30*
			* *18*
		- *UE can report one of following values for combination (2, 2) as a UE capability:*
			* *18*
			* *10*
	+ *For 30 kHz,*
		- *UE can report one of following values for combination (7, 3) as a UE capability:*
			* *36*
			* *28*
		- *UE can report one of following values for combination (4, 3) as a UE capability:*
			* *24*
			* *16*
		- *UE can report one of following values for combination (2, 2) as a UE capability:*
			* *16*
			* *8*

**Companies are encouraged to provide your views and your reasons**. If you have strong objection on the framework of either option 1 or option 2, please indicate here also. Considering we have to solve this issue by email discussions, please all of you to be constructive also.

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Ericsson (R1-2001784) and CATT (R1-2002082) also discuss the applicability to SCS 60 kHz and 120 kHz. Based on the discussion in previous meeting, it would be good for us to focus on finalizing 15 kHz and 30 kHz first.

**Issue B-3:** Capability on the number of CCs with Rel-16 monitoring capability

In the RAN1#99 meeting, the following agreement was made:

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| Agreement from RAN1#99UE reports its PDCCH monitoring capability for the following cases:* **Case 1**: Capability on the number of CCs with Rel-15 monitoring capability only
	+ This capability already exists in Rel-15
* **Case 2**: Capability on the number of CCs with Rel-16 monitoring capability only
	+ - pdcch-BlindDetectionCA-R16 can be smaller than 4
* **Case 3**: Capability on the number of CCs with Rel-15 monitoring capability and Rel-16 monitoring capability on different serving cells
	+ pdcch-BlindDetectionCA-R15 for Rel-15 PDCCH monitoring capability
	+ pdcch-BlindDetectionCA-R16 for Rel-16 PDCCH monitoring capability
		- Each of pdcch-BlindDetectionCA-R16 and pdcch-BlindDetectionCA-R15 can be smaller than 4
		- (The minimum of pdcch-BlindDetectionCA-R15 + The minimum of pdcch-BlindDetectionCA-R16) is not larger than 4
			* FFS (the minimum of pdcch-BlindDetectionCA-R15 + the minimum of pdcch-BlindDetectionCA-R16) can be smaller than 4

pdcch-BlindDetectionCA-R15 and pdcch-BlindDetectionCA-R16 for the above three cases can be reported separately |

**Case 2**: Some companies provide their view on *pdcch-BlindDetectionCA-R16* for case 2 explicitly. Some companies may implicitly provide their views from the value for case 3 by assuming any combination of (#Rel-16, #Rel-15) as long as the total number equal to 4. Note that the following in bracket is just my guess, if not correct please feel free to correct it when you reply.

* ***Option 1****：Minimum of pdcch-BlindDetectionCA-R16 = 4*
	+ *Support: [Ericsson], [Nokia], [CATT], [NTT DOCOMO], [Panasonic], Huawei/HiSilicon*
* ***Option 2****：Minimum of pdcch-BlindDetectionCA-R16 = 2*
	+ *Support: Qualcomm, [MTK], [Samsung], [Spreadtrum], [Apple]*

Considering also the values proposed by companies in section 4.1 and section 4.2, and in theory, it can be observed that the number of CC to be supported may be related to the value of M also. For example, it is possible that if the value of M is smaller, then more CC with Rel-16 capability can be supported, while a larger value of M may result in smaller number of CC to be supported. Therefore, if we really cannot achieve consensus to go with one single value, one alternative for us is to let UE to report as UE capability.

In Rel-15, candidate value for *pdcch-BlindDetectionCA* can be 4 to 16. Here assuming up to 16 carriers can be possible for UE supporting Rel-16 PDCCH monitoring capability also. The range for each option below is inferred from the proposals from different companies as the starting point of discussion, companies can further show your views.

***Proposal 4.1-3****: Further study the following options for the number of CCs with Rel-16 monitoring capability only on all the serving cells*

* ***Option 1****：Minimum of pdcch-BlindDetectionCA-R16 = 4*
	+ *Candidate values for pdcch-BlindDetectionCA-R16 is 4 to 16*
* ***Option 2****：Minimum of pdcch-BlindDetectionCA-R16 = 2*
	+ *Candidate values for pdcch-BlindDetectionCA-R16 is 2 to 8*
* ***Option 3****: Minimum of pdcch-BlindDetectionCA-R16 = 2*
	+ *Candidate values for pdcch-BlindDetectionCA-R16 is 2 to 16*

**Companies are encouraged to provide your preference and your reasons**. If you have strong objection on any option, please indicate here also. Considering we have to solve this issue by email discussions, please all of you to be constructive also.

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**Case 3**: Some companies provide views on case 3 as summarized as below:

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| Company | the minimum of pdcch-BlindDetectionCA-R15 + the minimum of pdcch-BlindDetectionCA-R16) can be smaller than 4 | Feature lead comment |
| Ericsson  | 4 | Comment #1: From feature lead perspective, it means that UE can support the combination of (#Rel-16, #Rel-15) as below:(4, 0)(3, 1)(2, 2)(1, 3)(0, 4) |
| Nokia | 4 | Similar as above comment #1  |
| MTK  | <4 (1 Rel 16 + 2 Rel-15) |  |
| CATT  | 4 | Similar as above comment #1 |
| Samsung  | < 4(1 Rel 16 + 2 Rel-15) |  |
| Spreadtrum  | < 4(1 Rel 16 + 2 Rel-15) |  |
| Qualcomm  | <4 (1 Rel + 2 Rel-15) |  |
| HW/HiSi  | 4 | Similar as above comment #1 |
| NTT DOCOMO | 4 |  |
| Apple  | <4 (1 Rel + 2 Rel-15) |  |
| Panasonic  | 4 |  |

As shown in the above table, company positions can be shown as below also:

* ***Option 1****：Minimum of* *pdcch-BlindDetectionCA-R15 + Minimum of pdcch-BlindDetectionCA-R1 = 4*
	+ *Support: Ericsson, Nokia, CATT, Huawei/HiSilicon, NTT DOCOMO, Panasonic*
* ***Option 2****：The minimum value of pdcch-BlindDetectionCA-R15 is 2 and the minimum value of pdcch-BlindDetectionCA-R16 is 1*
	+ *Support: MTK, Qualcomm, Samsung, Spreadtrum, Apple*

Based on the current agreement, the UE is to report a single Case 3 combination of pdcch-BlindDetectionCA-R15 and pdcch-BlindDetectionCA-R16. R1-2001694 expressed that this to be slightly restrictive, and proposes to support more than one case 3 combination (i.e. combination of pdcch-BlindDetectionCA-R15 + pdcch-BlindDetectionCA-R16) to be reported by the UE, to be able to operate the UE up to its full potential capability. For example, if UE only reports 2 R16 + 2 R15 for case 3, then if the gNB would only configure a single R16 CC based on the reported capability it would not know that actually 4 R15 CCs could be configured in addition as the reported capability only indicates 2 R15 CCs (i.e. gNB cannot configure the UE up to its full potential). From feature lead point of view, it seems a reasonable way to go.

In Rel-15, candidate value for *pdcch-BlindDetectionCA* can be 4 to 16. Here assuming up to 16 carriers can be possible for UE supporting Rel-16 PDCCH monitoring capability also. The range for each option below is inferred from the proposals from different companies as the starting point of discussion, companies can further show your views.

***Proposal 4.1-4****: For the case with Rel-15 monitoring capability and Rel-16 monitoring capability on different serving cells, UE will report pdcch-BlindDetectionCA-R15 and pdcch-BlindDetectionCA-R16 following one of the following options:*

* ***Option 1****：UE will report one combination of (pdcch-BlindDetectionCA-R15, pdcch-BlindDetectionCA-R16) as UE capability*
	+ *Minimum of pdcch-BlindDetectionCA-R15 + Minimum of pdcch-BlindDetectionCA-R16 = 4*
	+ *pdcch-BlindDetectionCA-R15 + pdcch-BlindDetectionCA-R16 <=16*
	+ *Candidate values for pdcch-BlindDetectionCA-R15 is 1 to 15*
	+ *Candidate values for pdcch-BlindDetectionCA-R16 is 1 to 15*
* ***Option 2****：UE will report one combination of (pdcch-BlindDetectionCA-R15, pdcch-BlindDetectionCA-R16) as UE capability*
	+ *The minimum value of pdcch-BlindDetectionCA-R15 is 2 and the minimum value of pdcch-BlindDetectionCA-R16 is 1*
	+ *pdcch-BlindDetectionCA-R15 + pdcch-BlindDetectionCA-R16 <16*
	+ *Candidate values for pdcch-BlindDetectionCA-R15 is 2 to 14*
	+ *Candidate values for pdcch-BlindDetectionCA-R16 is 1 to 7*
* ***Option 3****：UE will report more than one combination of (pdcch-BlindDetectionCA-R15, pdcch-BlindDetectionCA-R16) as UE capability*
	+ *Candidate values for pdcch-BlindDetectionCA-R15 is 1 to 15*
	+ *Candidate values for pdcch-BlindDetectionCA-R16 is 1 to 15*
	+ *pdcch-BlindDetectionCA-R15 + pdcch-BlindDetectionCA-R16 <=16*

**Companies are encouraged to provide your preference and your reasons**. If you have strong objection on any option, please indicate here also. Considering we have to solve this issue by email discussions, please all of you to be constructive also.

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**Issue B-4:** Switching between Rel-15 and Rel-16 PDCCH monitoring

Switching between Rel-15 and Rel-16 PDCCH monitoring configurations is also discussed in R1-2001998 (Intel).

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| *Contribution R1-2001998, Intel*In Rel-16 URLLC, PDCCH monitoring can be configured based on either Rel-15 capability (i.e. per slot-based capability) or Rel-16 capability (i.e. per span based capability) on a serving cell, and the gNB configures which capability is used. An RRC parameter has been defined, ‘*PDCCHMonitoringCapabilityConfig*’ (i.e., via an explicit bit-field in *PDCCHConfig*), to (re-)configure either Rel-15 or Rel-16 PDCCH monitoring configurations for PDCCH monitoring on a serving cell. By switching between the configurations, the SS set configuration (i.e., via higher layer IE *search-space-config*))) can be reconfigured (or some of the parameters under this IE can be reconfigured). As such, different options may be considered to properly handle the reconfiguration. For example,1. An optional (RRC) parameter can be introduced as part of the SS set configuration, to indicate which monitoring behavior the new configurations is associated to (particularly to indicate whether the search space set applies when the UE is configured with slot-level PDCCH monitoring or span-based PDCCH monitoring). While such design requires introduction of new RRC parameter to identify SS sets that apply for each monitoring configurations (i.e., Rel-15 vs. Rel-16), it may provide the most straightforward approach to enable the switching of monitoring configurations.
	1. Another, a bit more compact, signaling approach could be to configure a separate parameter/list in PDCCH-Config – listing the SS set indices associated with a PDCCH monitoring configuration (e.g., *R15PDCCHMonitoringSearchSpaceIdList, and R16PDCCHMonitoringSearchSpaceIdList*). This would be an alternative to the option of configuring a new parameter as part of **(each)** search space set to indicate whether the SS set is associated with either or both of Rel-15 and Rel-16 PDCCH monitoring configurations. A SS set can be in both lists. In terms of the RRC overhead, separate list of SS set indices would be more efficient compared to per SS set-tagging. If these parameters are not configured or a SS set is not listed under either configuration, then the concerned SS sets are expected to be monitored irrespective of the indication via *PDCCHMonitoringCapabilityConfig* (i.e., equivalent to being in both lists).
2. Alternatively, the UE may always rely on gNB’s SS set configuration (with no additional indication being introduced), when it indicates its capability of supporting Rel-16 on a particular carrier. This means that it can be left up to the gNB to ensure that the corresponding limits on number of BDs and non-overlapping CCEs are satisfied for both slot-based or span-based configurations, under the SS set configuration, and for a given serving cell. **Further, such approach incurs significantly high RRC signaling overhead, due to reconfigurations of SS sets as well as incur significant NW scheduler complexity in ensuring that the corresponding limits are satisfied across the set of configured search space sets, some of which (e.g., certain CSS configurations like *searchSpaceZero*) may need to be maintained across the switching events to maintain connectivity.**

In our view, given the overall tradeoffs between these mechanisms and the general benefits of Option 1-a, such design forms a suitable solution to enable the switching between PDCCH monitoring configurations in Rel-16 URLLC. Here, it should be further noted that specifying an efficient switching mechanism facilitates optimal switching between the two PDCCH monitoring configurations to achieve optimal trade-off between low latency performance and increased UE power consumption.**Proposal 4*** *The UE can be configured with one or both of RRC parameters that list the SS set indices associated with Rel-15 and Rel-16 PDCCH monitoring capability configuration (e.g., R15PDCCHMonitoringSearchSpaceIdList, and R16PDCCHMonitoringSearchSpaceIdList).*
	+ *A SS set can be in both lists.*
	+ *If this parameter/list is not configured or a SS set is not listed under either configuration, then the concerned SS sets are expected to be monitored irrespective of the indication via PDCCHMonitoringCapabilityConfig (i.e., equivalent to being in both lists).*
 |

***Proposal 4.1-5****:* *Further study whether/how to handle the issues due to switching between Rel-15 and Rel-16 PDCCH monitoring.*

Companies are encouraged to provide your views on whether you think it is an issue, and if yes what solution you prefer.

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## Scaling PDCCH monitoring capability if the number of CCs configured is larger than the reported capability

**Issue C-1:** How to define “aligned spans” and “non-aligned spans”?

Some companies provide views on how to define “aligned spans” and “non-aligned spans”. The proposals on how to define “aligned spans” and company positions are summarized as below. Note that for all the options, it is assumed that cases not satisfying the condition for “aligned spans” can be considered as “non-aligned spans”. Note that the description in some contributions might not be exactly the same as the options listed here, I put the company position according to my understanding. If it is not correct, please correct it when you reply also.

***Option 1:*** *a set of DL cells satisfying a common combination (X, Y) is said to have “aligned spans”* ***if and only if the PDCCH monitoring spans are aligned in time across all the cells****. Here, “aligned in time” can be defined such that all cells satisfy the following:*

* *total number of spans are the same across the DL cells, and*
* *the k-th span in a DL cell #i overlaps with the k-th span in any other cell #j from the set of* $N\_{cells,r16}^{DL,(X,Y),μ}$ *DL cells such that the* *cardinality of the union of the sets of symbols corresponding to the k-th span across all the* $N\_{cells,r16}^{DL,(X,Y),μ}$ *DL cells is no larger than Y.*
	+ *Support: Intel, [MTK], [CATT]*
	+ ***Feature lead comment****: Y here should be* $d\_{span}=max\left(d\_{CORESET,max},Y\_{min}\right)$*?*



**Example: Non-aligned span case**

***Option 2:*** *If for a span that starts from* **or ends at** *a symbol on a downlink cell from thedownlink cells, spans on all other downlink cells from the   downlink cells with overlapping symbols with the span start from* **or end at** *the symbol*

* + *Support: ZTE, [Spreadtrum]*



Example #1 for aligned spans case



Example #2: or aligned spans case



Figure 3 Example #3 for aligned spans case



Figure 4 Example #4 for aligned spans case

***Option 3:*** *Spans on cells from the* $N\_{cells,r16}^{DL,\left(X,Y\right),μ}$ *downlink cells are considered as aligned if the union of PDCCH monitoring occasions on all the cells results to PDCCH monitoring according to combination* $(X,Y)$

1. *are within a same set of up to* $Y$ *consecutive symbols, or*
2. *have first symbols separated by at least* $X$ *symbols*
	* *Support: Samsung*



***Option 4:*** *If for any span of a first CC, the starting symbol of the span is the same as (aligned with) the starting symbol of a span of a second CC, when the span of the first CC and the span of the second CC are overlapping*

* + *Support: Motorola/Lenovo,*

***Question 4.2-1:*** *Which option under issue C-1 in section 4.2 in R1-2002688 do you prefer for the definition of “aligned spans”? Please provide your reasons also.*

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In addition, Vivo (R1-2001669) raised a question whether we need to consider timing difference of received signaling from different Cells. The maximum receive timing difference is 3 µs and 33 µs for intra-band CA and inter-band CA in FR1 according to the requirement defined in RAN4[4]. For inter-band CA in FR1, timing difference of different Cells is approximately one OFDM symbol in 30 kHz SCS configuration, which is not negligible. The timing difference of received signaling transmitted by different Cells can also lead to ‘the unaligned span’, even the same span pattern is configured for all the Cells, as shown in the following Figure.



Figure timing difference of received signaling from different Cells

***Question 4.2-2:*** *Whether the timing difference of received signaling from different Cells is considered or not for aligned span and un-aligned span case?*

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In addition, Vivo (R1-2001669) also raised a question whether the back-to-back spans on different serving cells is an issue for Rel-16 PDCCH monitoring capability.

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| *Vivo R1-2001669* Figure 2 Rel-15 CA with 2 Cells, 30kHz SCSAccording to Rel-15 UE feature 3-1, which is a mandatory capability without capability signaling, CSS with some types can be located in any symbols within a slot, as shown in Figure2[3]. CSS1 of Cell 1 can be configured at the end of a slot, which is configured with 48 non-overlapping CCEs. USS 2 of Cell 2 for PDCCH scheduling unicast PDSCH is configured with 48 non-overlapping CCEs located at the beginning of an adjacent slot. In this case, “back-to-back” monitoring occasions can occur. It can be seen that the limit of non-overlapping CCEs for each slot is met in case of “back-to-back” monitoring occasion configuration, which has been supported in Rel-15. There is no extra limitation for the “back-to-back” monitoring occasions in Rel-15. The case described in Figure 1 is equivalent to the case depicted in Figure 2, except monitoring capability limit per span. Therefore, “back-to-back” monitoring occasion configuration across spans should be supported in Rel-16. |

***Question 4.2-3:*** *Whether the “back-to-back” spans on different serving cells is an issue considering similar cases exits in Rel-15 already?*

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**Issue C-2:** How to scale the monitoring capability for “non-aligned spans” case if the number of CCs configured is larger than the reported capability?

There had been extensive discussion in RAN1#100-e on how to handle the CA case when the reported capability is less than the actual configured number of CCs. It was acknowledged that there are two cases, namely with aligned spans and with non-aligned spans, and it makes sense to treat these two cases differently or independently.

For the case with aligned span, we have agreed on the following working assumptions:

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| Working assumption:    *If a UE is configured with* $N\_{cells,r16}^{DL,(X,Y),μ}$ *downlink cells with Rel-16 PDCCH monitoring capability with an associated combination (X, Y) and SCS configuration µ, where* $\sum\_{μ=0}^{1}N\_{cells,r16}^{DL,μ}>N\_{cells}^{cap-r16}$, *the UE is not required to monitor more than* $C\_{PDCCH}^{total,(X,Y),μ} $*non-overlapping CCEs per span on the active DL BWP(s) of scheduling cell(s) from the* $N\_{cells,r16}^{DL,(X,Y),μ} $*downlink cells if the spans on all downlink cells from the* $N\_{cells,r16}^{DL,(X,Y),μ}$ *downlink cells are aligned, where*$$C\_{PDCCH}^{total,(X,Y),μ}=\left⌊N\_{cells}^{cap-r16}⋅C\_{PDCCH}^{max,(X,Y),μ}⋅{\left(N\_{cells,r16}^{DL,(X,Y),μ}\right)}/{\sum\_{j=0}^{1}\left(N\_{cells,r16}^{DL,j}\right)}\right⌋$$* + $N\_{cells,r16}^{DL,j}$ *is the number serving cells configured with Rel-16 PDCCH monitoring capability with SCS configuration j.*
	+ *If a UE is configured with multiple carriers with a mix of Rel-15 and Rel-16 PDCCH monitoring capability,* $N\_{cells}^{cap-r16}$ *is replaced by* $N\_{cells,r16}^{cap-r16}$*.*
	+ *The associated combination (X, Y) is the combination (X, Y) associated with largest maximum number of* $C\_{PDCCH}^{max,\left(X,Y\right),μ}$ *, if the UE indicates a capability to monitor PDCCH according to multiple (X, Y) combinations and a configuration of search space sets to the UE results in ~~a span pattern with~~ a separation of any two consecutive PDCCH monitoring spans that is equal to or larger than the value of X for two or more of the (X, Y) combinations.*

*If a UE is configured with* $N\_{cells,r16}^{DL,(X,Y),μ}$ *downlink cells with Rel-16 PDCCH monitoring capability with an associated combination (X, Y) and SCS configuration µ, where* $\sum\_{μ=0}^{1}N\_{cells,r16}^{DL,μ}>N\_{cells}^{cap-r16}$, *the UE is not required to monitor more than* $M\_{PDCCH}^{total,(X,Y),μ} $*PDCCH candidates per span on the active DL BWP(s) of scheduling cell(s) from the* $N\_{cells,r16}^{DL,(X,Y),μ} $*serving cells if the spans on all downlink cells from the* $N\_{cells,r16}^{DL,(X,Y),μ}$ *downlink cells are aligned, where*$$M\_{PDCCH}^{total,(X,Y),μ}=\left⌊N\_{cells}^{cap-r16}⋅M\_{PDCCH}^{max,(X,Y),μ}⋅{\left(N\_{cells,r16}^{DL,(X,Y),μ}\right)}/{\sum\_{j=0}^{1}\left(N\_{cells,r16}^{DL,j}\right)}\right⌋$$* + $N\_{cells,r16}^{DL,j}$ *is the number serving cells configured with Rel-16 PDCCH monitoring capability with SCS configuration j.*
	+ *If a UE is configured with multiple carriers with a mix of Rel-15 and Rel-16 PDCCH monitoring capability,* $N\_{cells}^{cap-r16}$ *is replaced by* $N\_{cells,r16}^{cap-r16}$*.*
	+ *The associated combination (X, Y) is the combination (X, Y) associated with largest maximum number of* $M\_{PDCCH}^{max,(X,Y),μ}$*, if the UE indicates a capability to monitor PDCCH according to multiple (X, Y) combinations and a configuration of search space sets to the UE results in ~~a span pattern with~~ a separation of any two consecutive PDCCH monitoring spans that is equal to or larger than the value of X for two or more of the (X, Y) combinations.*
 |

There had been discussions during RAN1#100-e on the related operation for non-aligned spans, but no agreement could be achieved. In the FL summary in R1-2001409, proposals 1 and 2 are noted for possible agreement for non-aligned spans:

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| ***Proposal #1:*** *If a UE is configured with* $N\_{cells,r16}^{DL,(X,Y),μ}$ *downlink cells with Rel-16 PDCCH monitoring capability with an associated combination (X, Y) and SCS configuration µ, where* $\sum\_{μ=0}^{1}N\_{cells,r16}^{DL,μ}>N\_{cells}^{cap-r16}$, *the UE is not required to monitor more than* $C\_{PDCCH}^{total,(X,Y),μ} $*non-overlapping CCEs for any set of spans across the active DL BWP(s) of scheduling cell(s) from the* $N\_{cells,r16}^{DL,(X,Y),μ} $*downlink cells if the spans on different downlink cells from the* $N\_{cells,r16}^{DL,(X,Y),μ}$ *downlink cells are not aligned, with at most one span per scheduling cell for each set, where*$$C\_{PDCCH}^{total,(X,Y),μ}=\left⌊N\_{cells}^{cap-r16}⋅C\_{PDCCH}^{max,(X,Y),μ}⋅{\left(N\_{cells,r16}^{DL,(X,Y),μ}\right)}/{\sum\_{j=0}^{1}\left(N\_{cells,r16}^{DL,j}\right)}\right⌋$$* + $N\_{cells,r16}^{DL,j} $*is the number serving cells configured with Rel-16 PDCCH monitoring capability with SCS configuration j.*
	+ *If a UE is configured with multiple carriers with a mix of Rel-15 and Rel-16 PDCCH monitoring capability,* $N\_{cells}^{cap-r16}$ *is replaced by* $N\_{cells,r16}^{cap-r16}$*.*
	+ *The associated combination (X, Y) is the combination (X, Y) associated with largest maximum number of* $C\_{PDCCH}^{max,\left(X,Y\right),μ}$ *, if the UE indicates a capability to monitor PDCCH according to multiple (X, Y) combinations and a configuration of search space sets to the UE results in a span pattern with a separation of any two consecutive PDCCH monitoring spans that is equal to or larger than the value of X for two or more of the (X, Y) combinations.*

 ***Proposal #2****: If a UE is configured with* $N\_{cells,r16}^{DL,(X,Y),μ}$ *downlink cells with Rel-16 PDCCH monitoring capability with an associated combination (X, Y) and SCS configuration µ, where* $\sum\_{μ=0}^{1}N\_{cells,r16}^{DL,μ}>N\_{cells}^{cap-r16}$, *the UE is not required to monitor more than* $M\_{PDCCH}^{total,(X,Y),μ} $*PDCCH candidates for any set of spans across the active DL BWP(s) of scheduling cell(s) from the* $N\_{cells,r16}^{DL,(X,Y),μ} $*downlink cells if the spans on different downlink cells from the* $N\_{cells,r16}^{DL,(X,Y),μ}$ *downlink cells are not aligned, with at most one span per scheduling cell for each set, where*$$M\_{PDCCH}^{total,(X,Y),μ}=\left⌊N\_{cells}^{cap-r16}⋅M\_{PDCCH}^{max,(X,Y),μ}⋅{\left(N\_{cells,r16}^{DL,(X,Y),μ}\right)}/{\sum\_{j=0}^{1}\left(N\_{cells,r16}^{DL,j}\right)}\right⌋$$* + $N\_{cells,r16}^{DL,j} $*is the number serving cells configured with Rel-16 PDCCH monitoring capability with SCS configuration j.*
	+ *If a UE is configured with multiple carriers with a mix of Rel-15 and Rel-16 PDCCH monitoring capability,* $N\_{cells}^{cap-r16}$ *is replaced by* $N\_{cells,r16}^{cap-r16}$*.*
	+ *The associated combination (X, Y) is the combination (X, Y) associated with largest maximum number of* $M\_{PDCCH}^{max,(X,Y),μ}$*, if the UE indicates a capability to monitor PDCCH according to multiple (X, Y) combinations and a configuration of search space sets to the UE results in a span pattern with a separation of any two consecutive PDCCH monitoring spans that is equal to or larger than the value of X for two or more of the (X, Y) combinations.*
 |

For simplicity, let’s focus on the scaling for the non-overlapping CCEs first, and once we achieve agreement on the non-overlapping CCEs, the corresponding proposal for the maximum number of monitored PDCCH candidates can be achieved. Based on the views in the contributions, the candidate options and company positions are summarized below. Note that some options are not exactly the same as what I listed here, I try to complete it according to my understanding. If it is not correct, please correct it when you reply.

***Option 1 (proposal 1 from FL summary R1-2001409):*** *If a UE is configured with* $N\_{cells,r16}^{DL,(X,Y),μ}$ *downlink cells with Rel-16 PDCCH monitoring capability with an associated combination (X, Y) and SCS configuration µ, where* $\sum\_{μ=0}^{1}N\_{cells,r16}^{DL,μ}>N\_{cells}^{cap-r16}$, *the UE is not required to monitor more than* $C\_{PDCCH}^{total,(X,Y),μ} $*non-overlapping CCEs for any set of spans across the active DL BWP(s) of scheduling cell(s) from the* $N\_{cells,r16}^{DL,(X,Y),μ} $*downlink cells if the spans on different downlink cells from the* $N\_{cells,r16}^{DL,(X,Y),μ}$ *downlink cells are not aligned, with at most one span per scheduling cell for each set, where*

$$C\_{PDCCH}^{total,(X,Y),μ}=\left⌊N\_{cells}^{cap-r16}⋅C\_{PDCCH}^{max,(X,Y),μ}⋅{\left(N\_{cells,r16}^{DL,(X,Y),μ}\right)}/{\sum\_{j=0}^{1}\left(N\_{cells,r16}^{DL,j}\right)}\right⌋$$

* + $N\_{cells,r16}^{DL,j} $*is the number serving cells configured with Rel-16 PDCCH monitoring capability with SCS configuration j.*
	+ *If a UE is configured with multiple carriers with a mix of Rel-15 and Rel-16 PDCCH monitoring capability,* $N\_{cells}^{cap-r16}$ *is replaced by* $N\_{cells,r16}^{cap-r16}$*.*
	+ *The associated combination (X, Y) is the combination (X, Y) associated with largest maximum number of* $C\_{PDCCH}^{max,\left(X,Y\right),μ}$ *, if the UE indicates a capability to monitor PDCCH according to multiple (X, Y) combinations and a configuration of search space sets to the UE results in a span pattern with a separation of any two consecutive PDCCH monitoring spans that is equal to or larger than the value of X for two or more of the (X, Y) combinations.*
	+ *Support: Nokia, Intel, MTK, Qualcomm, CATT, Spreatrum*
	+ *Reasons for supporting this option:*
		- *Non-aligned spans across the DL cells satisfying a given combination (X, Y) itself is not typical case, thus some restriction is acceptable.*
	+ *Reasons for not supporting this option:*
		- *Lead to severe restriction for search space configuration in that all combinations of spans across downlink cells have to obey the CA limit even if some spans are not located close to each other in time, contradicting the intention of Rel-16 PDCCH monitoring capability per span*

***Option 2****: If a UE is configured with* $N\_{cells,r16}^{DL, cell set i,(X,Y),μ}$ *downlink cells with Rel-16 PDCCH monitoring capability with an associated combination (X, Y) and SCS configuration µ, where* $\sum\_{μ=0}^{1}N\_{cells,r16}^{DL,μ}>N\_{cells}^{cap-r16}$, *the UE is not required to monitor more than* $C\_{PDCCH}^{total, cell set i,(X,Y),μ} $*non-overlapping CCEs per span on the active DL BWP(s) of scheduling cell(s) from the* $N\_{cells,r16}^{DL, cell set i,(X,Y),μ} $*downlink cells if the spans on all downlink cells from the* $N\_{cells,r16}^{DL, cell set i,(X,Y),μ}$ *downlink cells are aligned, where*

$$C\_{PDCCH}^{total, cell set i,(X,Y),μ}=\left⌊N\_{cells}^{cap-r16}⋅C\_{PDCCH}^{max,(X,Y),μ}⋅{\left(N\_{cells,r16}^{DL, cell set i,(X,Y),μ}\right)}/{\sum\_{j=0}^{1}\left(N\_{cells,r16}^{DL,j}\right)}\right⌋$$

* + *The* $N\_{cells,r16}^{DL, cell set i,(X,Y),μ}$*is the number of cells from the cell set with same numerology* $μ$*, same associated combination (X, Y) and that are satisfying aligned-span condition.*
	+ $N\_{cells,r16}^{DL,j}$*is the number serving cells configured with Rel-16 PDCCH monitoring capability with SCS configuration j.*
	+ *If a UE is configured with multiple carriers with a mix of Rel-15 and Rel-16 PDCCH monitoring capability,* $N\_{cells}^{cap-r16}$ *is replaced by* $N\_{cells,r16}^{cap-r16}$*.*
	+ *The associated combination (X, Y) is the combination (X, Y) associated with largest maximum number of* $C\_{PDCCH}^{max,\left(X,Y\right),μ}$ *, if the UE indicates a capability to monitor PDCCH according to multiple (X, Y) combinations and a configuration of search space sets to the UE results in a separation of any two consecutive PDCCH monitoring spans that is equal to or larger than the value of X for two or more of the (X, Y) combinations.*
	+ *Support: Huawei/HiSilicon, [Quectel]*
	+ *Reasons*
		- *Remove the restriction among the carriers with aligned span cases*

***Option 3:*** *If a UE is configured with* $N\_{cells,r16}^{DL,(X,Y),μ}$ *downlink cells with Rel-16 PDCCH monitoring capability with an associated combination (X, Y) and SCS configuration µ, where* $\sum\_{μ=0}^{1}N\_{cells,r16}^{DL,μ}>N\_{cells}^{cap-r16}$, *the UE is not required to monitor more than* $C\_{PDCCH}^{total,(X,Y),μ} $*non-overlapping CCEs for any set of spans present in the same DL-sub-slot across the active DL BWP(s) of scheduling cell(s) from the* $N\_{cells,r16}^{DL,(X,Y),μ} $*downlink cells, with at most one span per scheduling cell for each set, where*

$$C\_{PDCCH}^{total,(X,Y),μ}=\left⌊N\_{cells}^{cap-r16}⋅C\_{PDCCH}^{max,(X,Y),μ}⋅{\left(N\_{cells,r16}^{DL,(X,Y),μ}\right)}/{\sum\_{j=0}^{1}\left(N\_{cells,r16}^{DL,j}\right)}\right⌋$$

* + $N\_{cells,r16}^{DL,j} $*is the number serving cells configured with Rel-16 PDCCH monitoring capability with SCS configuration j.*
	+ *If a UE is configured with multiple carriers with a mix of Rel-15 and Rel-16 PDCCH monitoring capability,* $N\_{cells}^{cap-r16}$ *is replaced by* $N\_{cells,r16}^{cap-r16}$*.*
	+ *The associated combination (X, Y) is the combination (X, Y) associated with largest maximum number of* $C\_{PDCCH}^{max,\left(X,Y\right),μ}$ *, if the UE indicates a capability to monitor PDCCH according to multiple (X, Y) combinations and a configuration of search space sets to the UE results in a span pattern with a separation of any two consecutive PDCCH monitoring spans that is equal to or larger than the value of X for two or more of the (X, Y) combinations.*
	+ *The DL-sub-slot pattern for* $N\_{cells,r16}^{DL,(X,Y),μ}$ *of the* $N\_{cells,r16}^{DL,μ}$ *downlink cells using combination* $\left(X,Y\right) $*and SCS configuration* $μ$ *is determined as follows. First a bitmap b(l), 0<=l<=13 is generated, where b(l)=1 if symbol l of a slot is the starting symbol of a monitoring span of the relevant DL cells/component carriers, b(l)=0 otherwise. The first DL-sub-slot in the DL-sub-slot pattern begins at the smallest l for which b(l)=1. The next DL-sub-slot in the DL-sub-slot pattern begins at the smallest l not included in the previous DL-sub-slot(s) for which b(l)=1. The DL-sub-slot duration is equal to X symbols, except possibly the last DL-sub-slot in a slot which can be of shorter duration than X. DL-sub-slot do not overlap. Every DL-sub-slot is contained in a single slot. The same DL-sub-slot pattern repeats in every slot.*
	+ *Support: Ericsson*
	+ *Reasons*
		- *Remove the restriction to spans that is far away each other*



Figure Example of sets of spans present in the same DL-sub-slot across the active DL BWP(s) of scheduling cell(s) with at most one span per scheduling cell for each set. Note that each span is present in/ overlap in time with one or more DL-sub-slots in the DL-sub-slot pattern.



Figure Example of sets of spans present in the same DL-sub-slot across the active DL BWP(s) of scheduling cell(s) with at most one span per scheduling cell for each set.

***Option 4:*** *If a UE is configured with*  *downlink cells with Rel-16 PDCCH monitoring capability, and with*  *of the  downlink cells using combination (X, Y) for PDCCH monitoring, and having active DL BWPs using SCS configuration µ, where* , *the UE is not required to monitor more than non-overlapping CCEs for any set of* ***a group of overlapping*** *spans across the active DL BWP(s) of scheduling cell(s) from the* *downlink cells if the spans on different downlink cells from the*  *downlink cells are not aligned, with at most one span per scheduling cell for each set.*

* *For a given span, the group of overlapping spans is defined that the span within the group overlaps with any other span(s) if any in the group.*
* *The notations above have the same definition as the aligned span case.*
	+ *Support: ZTE, [OPPO]*

***Option 5:*** *If a UE is configured with* $N\_{cells,r16}^{DL,(X,Y),μ}$ *downlink cells with Rel-16 PDCCH monitoring capability,* $\sum\_{μ=0}^{1}N\_{cells,r16}^{DL,μ}>N\_{cells}^{cap-r16}$, *the UE is not required to monitor more than* $C\_{PDCCH}^{total,(X,Y),μ} $*non-overlapping CCEs per span on the active DL BWP(s) of scheduling cell(s) from the* $N\_{cells,r16}^{DL,(X,Y),μ} $*downlink cells, where*

$$C\_{PDCCH}^{total,(X,Y),μ}=\left⌊N\_{cells}^{cap-r16}⋅C\_{PDCCH}^{max,(X,Y),μ}⋅{\left(N\_{cells,r16}^{DL,(X,Y),μ}\right)}/{\sum\_{j=0}^{1}\left(N\_{cells,r16}^{DL,j}\right)}\right⌋$$

* + *For a given span of a given cell,* $N\_{cells,r16}^{DL,j}$ *is the number of serving cells configured with Rel-16 PDCCH monitoring capability with SCS configuration j and with overlapping spans.*
	+ *For given span of a given cell and given SCS,* $N\_{cells,r16}^{DL,(X,Y),μ} $*is determined by the number of cells with the overlapping spans with the same span pattern and with an associated combination (X, Y)*
	+ *If a UE is configured with multiple carriers with a mix of Rel-15 and Rel-16 PDCCH monitoring capability,* $N\_{cells}^{cap-r16}$ *is replaced by* $N\_{cells,r16}^{cap-r16}$*.*
	+ *The associated combination (X, Y) is the combination (X, Y) associated with largest maximum number of* $C\_{PDCCH}^{max,\left(X,Y\right),μ}$ *, if the UE indicates a capability to monitor PDCCH according to multiple (X, Y) combinations and a configuration of search space sets to the UE results in ~~a span pattern with~~ a separation of any two consecutive PDCCH monitoring spans that is equal to or larger than the value of X for two or more of the (X, Y) combinations.*
	+ *Support: Vivo,*
	+ *Reasons*
		- *Fully utilize the UE monitoring capability*
		- *Cons:*
			* *UE needs to calculate the limit per span*



Example: for span 1 of Cell 1, the overlapping cell -span combination set is {Cell 1(2,2), Cell 2 (4,3)}

***Option 6:*** *If a UE is configured with* $N\_{cells,r16}^{DL,(X,Y),μ}$ *downlink cells with Rel-16 PDCCH monitoring capability with an associated combination (X, Y) and SCS configuration µ, where* $\sum\_{μ=0}^{1}N\_{cells,r16}^{DL,μ}>N\_{cells}^{cap-r16}$, and *if the spans on all downlink cells from the* $N\_{cells,r16}^{DL,\left(X,Y\right),g,μ}$ *downlink cells are aligned for g={1,2,…,G},the UE is not required to monitor more than* $C\_{PDCCH}^{total,\left(X,Y\right),μ} $*non-overlapping CCEs for any set of spans across the active DL BWP(s) of scheduling cell(s) from the* $N\_{cells,r16}^{DL,\left(X,Y\right),G+1,μ} $*downlink cells and a/any downlink cell from the* $N\_{cells,r16}^{DL,\left(X,Y\right),g,μ}$ *downlink cells if the spans on downlink cells from the* $N\_{cells,r16}^{DL,\left(X,Y\right), μ}$ *downlink cells are not aligned, with at most one span per scheduling cell for each set of spans, where*

$$C\_{PDCCH}^{total,\left(X,Y\right),μ}=\left⌊N\_{cells}^{cap-r16}⋅C\_{PDCCH}^{max,\left(X,Y\right),μ}⋅{\left(N\_{cells,r16}^{DL,\left(X,Y\right),μ}\right)}/{\sum\_{j=0}^{1}\left(N\_{cells,r16}^{DL,j}\right)}\right⌋$$

* + *is the number serving cells configured with Rel-16 PDCCH monitoring capability with SCS configuration j.*
	+ $\sum\_{g=1}^{G+1}N\_{cells,r16}^{DL,\left(X,Y\right),g,μ}=N\_{cells,r16}^{DL,\left(X,Y\right),μ}$.
	+ *If a UE is configured with multiple carriers with a mix of Rel-15 and Rel-16 PDCCH monitoring capability,* $N\_{cells}^{cap-r16}$ *is replaced by.*
	+ *The associated combination (X, Y) is the combination (X, Y) associated with largest maximum number of* $C\_{PDCCH}^{max,\left(X,Y\right),μ}$ *, if the UE indicates a capability to monitor PDCCH according to multiple (X, Y) combinations and a configuration of search space sets to the UE results in a span pattern with a separation of any two consecutive PDCCH monitoring spans that is equal to or larger than the value of X for two or more of the (X, Y) combinations.*
	+ *Support: Motorola/Lenovo,*

***Option 7:*** *For R16 PDCCH monitoring, the UE does not expect to be configured with multiple DL cells satisfying a given combination (X, Y) with non-aligned spans.*

* + *Support: Intel*
	+ *Reasons*
		- *Non-aligned spans across the DL cells satisfying a given combination (X, Y) itself is questionable.*

From feature lead point of view, option 2 to option 6 are trying to optimize by removing the restriction from proposal 1 to some extent. Option 3 above is similar as what feature lead proposed during the email discussion by adding “*within any X consecutive symbols*” in the proposals which also addresses the back-to-back span issues raised during the email discussion, while option 3 seems can be considered as “*within X consecutive symbols*” which cannot solve the back-to-back span issue. All the options seem have its pros and cons. Though we may need to see the views from companies on the above options first, based on the past discussion, from feature lead perspective I would suggest companies to consider option 1.

***Question 4.2-4:*** *Which option under issue C-2 in section 4.2 in R1-2002688 do you prefer for scaling PDCCH monitoring capability for “non-aligned spans” case? Can you accept option 1 even though it is not exactly what you are proposing to be constructive? Please provide your reasons.*

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Please note that once the potential direction for non-overlapping CCEs is clear, we can make proposals for monitored PDCCH candidates accordingly.

Note that Samsung and Apple also mentioned to extend the R16 PDCCH capability to multi-TRP case, while Quectel proposes that multiple DCIs scheduling multiple PDSCHs and Span based PDCCH monitoring are not supported simultaneously in a serving cell.

**Issue C-3:** Enhanced PDCCH monitoring capability for cross-carrier scheduling

Intel (R1-2001998) and Quectel (R1-2001813) discusses Rel-16 PDCCH monitoring capability for cross-carrier scheduling case. Two alternatives were discussed in the contributions:

* **Alt-1**: Both the scheduling cell and scheduled cell for cross-carrier scheduling are restricted to be configured the same PDCCH monitoring capability (i.e., *Rel-15 PDCCH monitoring capability* or *Rel-16 PDCCH monitoring capability*) , and provided the same combination when *Rel-16 PDCCH monitoring capability* is configured,
	+ *Support: Intel*
	+ *Reasons:*
		- *To simplify the PDCCH BD/CCE dimensioning and overall operation considering typical use cases*
* **Alt-2**: The calculations of $M\_{PDCCH}^{total,(X,Y),μ}$and $C\_{PDCCH}^{total,(X,Y),μ}$are based on the number of scheduled cells whose scheduling cells are configured with the same PDCCH monitoring capability and provided the same combination (X, Y) when *Rel-16 PDCCH monitoring capability* is configured.
	+ *Support: Quectel*
	+ *Reasons:*
		- *Does not prohibit the use of cross-carrier scheduling with different PDCCH monitoring capabilities or with different combinations and maintains the scheduling flexibility with limited specification efforts*

Companies are encouraged to provide your views on the above issue.

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## PDCCH candidate overbooking and dropping

**Issue D-1:** Span(s) for PDCCH overbooking/dropping

Over how many and which spans overbooking/dropping should be allowed was discussed in RAN1#100-e, and some candidate options were identified for further discussion.

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| ***Proposal #1****: For PDCCH overbooking/dropping, down select one from the following options:*       ***Option 1****：PDCCH overbooking/dropping is only performed in a span with CSS present*o   ***Alt. 1****: All span(s) with CSS present within a slot, including type-3 CSS*o   ***Alt. 2****: All span(s) with CSS present within a slot, except for type-3 CSS*o   ***Alt. 3****: At most X span(s) with CSS present within a slot, including type-3 CSS*   *FFS: If the number of spans with CSS present within a slot is larger than X, then PDCCH overbooking/dropping is performed in the first X spans with CSS present*  *For the value of X,** + - * *Alt.3-1: X=2*
			* *Alt.3-2: X=1*
			* *Alt.3-3: X is UE capability, the candidate value for X is {1, 2, FFS}*

        ***Option 2****：PDCCH overbooking/dropping is only performed in at most X span(s) within a slot;*o   ***Alt. 1****: the value of X is 1*o   ***Alt. 2****: X is UE capability, the candidate value for X is {1, 2, FFS}*        ***Option 3:*** *PDCCH overbooking is allowed in any span regardless of whether CSS is present in a span.* |

Based on the views in the contribution and the discussion in RAN1#100-e meeting, company positions are summarized as below:

       ***Option 1****：PDCCH overbooking/dropping is only performed in a span with CSS present*

* + ***Alt. 1****: All span(s) with CSS present within a slot, including type-3 CSS*
		- *Support: Nokia (2nd), Vivo, CATT, Panasonic, Sharp*
	+ ***Alt. 2****: All span(s) with CSS present within a slot, except for type-3 CSS*
	+ ***Alt. 3****: At most X span(s) with CSS present within a slot, including type-3 CSS*
		- *Support: Vivo, MTK, Huawei/HiSilicon, Apple, LG*

  *FFS: If the number of spans with CSS present within a slot is larger than X, then PDCCH overbooking/dropping is performed in the first X spans with CSS present*

  *For the value of X,*

* + - * *Alt.3-1: X=2*
			* *Alt.3-2: X=1*
			* *Alt.3-3: X is UE capability, the candidate value for X is {1, 2, FFS}*
				+ *Support: Huawei/HiSilicon, Apple, LG*

        ***Option 2****：PDCCH overbooking/dropping is only performed in at most X span(s) within a slot;*

* + *For the location of the X span(s)*
		- ***Alt.1****: The location information of X span(s) to perform PDCCH overbooking/dropping can be configured by higher layer signaling*
			* *Support: LG*
		- ***Alt.2****: If the number of spans present within a slot is larger than X, then PDCCH overbooking/dropping is performed in the first X spans*
	+ *For the value of X*
		- ***Alt. 1****: the value of X is 1*
			* *Support: Qualcomm*
		- ***Alt. 2****: X is UE capability, the candidate value for X is {1, 2, FFS}*
			* *Support: Spreadtrum, LG*
* ***Option 3:*** *PDCCH overbooking is allowed in any span regardless of whether CSS is present in a span.*
	+ *Support: Nokia, Ericsson, ZTE, Samsung, NTT DOCOMO, OPPO*
	+ *Reason*
		- *In Rel-15 overbooking is allowed in any slot regardless of whether CSS is present or not, similar rule should be used for Rel-16*
		- ***ZTE****: The CCE/BD counting could be done mostly offline once after corresponding RRC is updated*
		- ***Samsung****:*
			* *A benefit from limiting the number of spans where the UE checks for search space set dropping is also unclear as the worst case complexity scenario for such checking is for (X, Y) = (2, 2) and 30 kHz SCS which is practically same as in Rel-15 for slot-based checking and 120 kHz SCS. This is not an FR1 vs FR2 aspect as it onlys relates to software capability.*
			* *The possible combinations of search space sets at a given span are known in advance through the RRC configurations and search space sets to be dropped can be pre-determined.*
			* *Re-using the Rel-15 procedure avoids changing UE/gNB implementations for span-based PDCCH monitoring while there are no additional processing requirements compared to Rel-15.*

Based on the above positions, and considering the concerns from companies, for progress from feature lead perspective I would suggest to down-select to the following two options for further discussion. Hopefully companies can accept it and focus on the discussion of the two options here.

***Question 4.2-5:*** *Which option do you prefer for span(s) for PDCCH overbooking and dropping? Please provide your reasons.*

* ***Option 1:*** *PDCCH overbooking is allowed in any span regardless of whether CSS is present in a span.*
* ***Option 2****：PDCCH overbooking/dropping is only performed in at most X span(s) with CSS present within a slot, including type-3 CSS*
	+ *If the number of spans present within a slot is larger than X, then PDCCH overbooking/dropping is performed in the first X spans with CSS present*
	+ *For the value of X*
		- ***Alt. 2-1****: the value of X is 1*
		- ***Alt. 2-2****: X is UE capability, the candidate value for X is {1, 2, FFS}*

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**Issue D-2:** How to perform PDCCH dropping in a span

It was also discussed how dropping should be performed within a span. In particular, the following was listed for further consideration in the FL summary of R1-2001408 in Sec. 2.2.4:

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| ***Proposal #2****: PDCCH candidate dropping in a span, down select one from the following options:** ***Option 1****(i.e. original option 2)****:****If the number of non-overlapping CCE for channel estimation of the configured PDCCH candidates to monitor in some monitoring span j exceeds the CCE limit per monitoring span of the span j, UE can skip monitoring all PDCCH candidates in the search space sets with highest search space set indices in span j until the number of non-overlapping CCE of remaining PDCCH candidates to monitor in the monitoring span j does not exceed the CCE limit per monitoring span for span j, i.e. no partial dropping in any search space set*
* ***Option 2****(i.e. original option 3)****:****If the number of non-overlapping CCE for channel estimation of the configured PDCCH candidates to monitor in some monitoring span j exceeds the CCE limit per monitoring span of the span j, UE can skip monitoring some PDCCH candidates in the search space sets with highest search space set indices in span j until the number of non-overlapping CCE of remaining PDCCH candidates to monitor in the monitoring span j does not exceed the CCE limit per monitoring span for span j.*
 |

Based on the views in the contribution, company positions are summarized as below:

* ***Option 1:****If the number of non-overlapping CCE for channel estimation of the configured PDCCH candidates to monitor in some monitoring span j exceeds the CCE limit per monitoring span of the span j, UE can skip monitoring all PDCCH candidates in the search space sets with highest search space set indices in span j until the number of non-overlapping CCE of remaining PDCCH candidates to monitor in the monitoring span j does not exceed the CCE limit per monitoring span for span j, i.e. no partial dropping in any search space set*
	+ *Support:* *Nokia, Intel, Huawei/HiSilicon, Vivo, MTK, Samsung, Apple, OPPO, Panasonic*
	+ *Reasons*
		- *Almost no effort on spec change with option 1*
			* *Option 2 needs to discuss and define detailed dropping rules (or order) within the SSS of highest mapped index, we may have no sufficient time due to CR phase*
		- *No increase of UE complexity*
			* *Option 2 would increase UE complexity in terms of either online calculation of PDCCH candidates or higher storage requirements related monitoring for certain slots /spans*
* ***Option 2 :****If the number of non-overlapping CCE for channel estimation of the configured PDCCH candidates to monitor in some monitoring span j exceeds the CCE limit per monitoring span of the span j, UE can skip monitoring some PDCCH candidates in the search space sets with highest search space set indices in span j until the number of non-overlapping CCE of remaining PDCCH candidates to monitor in the monitoring span j does not exceed the CCE limit per monitoring span for span j.*
	+ *Support: NTT DOCOMO, Sharp*
	+ *Reason*
		- *Per-span limit is typically smaller than the per-slot limit, UE should monitor as many PDCCH candidates as possible*
* ***Option 3:***
	+ ***For single serving cell case****: If the number of non-overlapping CCE for channel estimation of the configured PDCCH candidates to monitor in some monitoring span j exceeds the CCE limit per monitoring span of the span j, UE can skip monitoring all PDCCH candidates in the search space sets with highest search space set indices in span j until the number of non-overlapping CCE of remaining PDCCH candidates to monitor in the monitoring span j does not exceed the CCE limit per monitoring span for span j, i.e. no partial dropping in any search space set.*
	+ ***For CA case****:* *If the total number of configured PDCCH candidates or non-overlapped CCEs summed over all spans in the set exceeds the CA limit* $M\_{PDCCH}^{total,(X,Y),μ}$ *or* $C\_{PDCCH}^{total,(X,Y),μ}$*, and where set* $R$ *is a set of spans which are present in the same DL-sub-slot across the active DL BWP(s) of scheduling cell(s) from the* $N\_{cells,r16}^{DL,(X,Y),μ} $*downlink cells, with at most one span per scheduling cell for each set, UE can skip monitoring all PDCCH candidates in the search space sets with highest search space set indices in the span in the DL-sub-slot until the number of non-overlapping CCE of remaining PDCCH candidates to monitor in the span in the DL-sub-slot does not exceed the CCE limit per monitoring span for the span in the DL-sub-slot, i.e. no partial dropping in any search space set.*
	+ *Support: Ericsson*

Based on the above views, for progress and simplicity, companies are encouraged to go with the majority view, i.e. option 1.

***Proposal 4.3-1****: If the number of non-overlapping CCE for channel estimation of the configured PDCCH candidates to monitor in some monitoring span j exceeds the CCE limit per monitoring span of the span j, UE can skip monitoring all PDCCH candidates in the search space sets with highest search space set indices in span j until the number of non-overlapping CCE of remaining PDCCH candidates to monitor in the monitoring span j does not exceed the CCE limit per monitoring span for span j, i.e. no partial dropping in any search space set.*

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## Miscellaneous corrections

**Issue E-1:** Correction on determination of a combination (X, Y) for PDCCH monitoring in section 10.1 in TS 38.213

Samsung (R1-2002131) proposes to adopt the following TP, to cover the case that a configuration of search space sets for PDCCH monitoring results to a separation of every two consecutive PDCCH monitoring spans that is equal to or larger than the value of $X$ for only one of the multiple combinations $\left(X,Y\right)$.

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| If the UE indicates a capability to monitor PDCCH according to multiple $\left(X,Y\right)$ combinations and a configuration of search space sets to the UE for PDCCH monitoring on a cell results to a separation of every two consecutive PDCCH monitoring spans that is equal to or larger than the value of $X$ for one or more combinations $\left(X,Y\right)$ of the multiple combinations $\left(X,Y\right)$, the UE is expected to monitor PDCCH on the cell according to the combination $\left(X,Y\right)$ from the one or more combinations $\left(X,Y\right)$ associated with the largest maximum number of $C\_{PDCCH}^{max,\left(X,Y\right),μ}$ and $M\_{PDCCH}^{max,\left(X,Y\right),μ}$. |

From feature lead point of view, the current spec should be clear even without the changes, but no harm to make it clear. If time permits, we can discuss and endorse the TP.

***Proposal 4.4-1:*** *Adopt the following TP on determination of a combination (X, Y) for PDCCH monitoring in section 10.1 in TS 38.213.*

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| If the UE indicates a capability to monitor PDCCH according to multiple $\left(X,Y\right)$ combinations and a configuration of search space sets to the UE for PDCCH monitoring on a cell results to a separation of every two consecutive PDCCH monitoring spans that is equal to or larger than the value of $X$ for one or more combinations $\left(X,Y\right)$ of the multiple combinations $\left(X,Y\right)$, the UE is expected to monitor PDCCH on the cell according to the combination $\left(X,Y\right)$ from the one or more combinations $\left(X,Y\right)$ associated with the largest maximum number of $C\_{PDCCH}^{max,\left(X,Y\right),μ}$ and $M\_{PDCCH}^{max,\left(X,Y\right),μ}$. |

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**Issue E-2:** Correction on span duration

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| *LG R1-2001919*

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| 10 UE procedure for receiving control information**<Unchanged text is omitted>**A UE reports one or more combinations of $\left(X,Y\right)$ number of symbols, where $X\geq Y$, for PDCCH monitoring. A span is a set of consecutive symbols in a slot in which the UE is configured to monitor PDCCH candidates. The UE supports PDCCH monitoring occasions in any symbol of a slot with minimum time separation of X symbols between the first symbol of two consecutive spans, including across slots. The duration of a span is $d\_{span}=max\left(d\_{CORESET,max},Y\_{min}\right)$, where $d\_{CORESET,max}$ is a maximum duration among durations of CORESETs that are configured to the UE and $Y\_{min}$ is a minimum value of $Y$ in the combinations of $\left(X,Y\right)$ that are reported by the UE. A last span in a slot can have a shorter duration than other spans in the slot.  |

The highlighted part in yellow should be re-assessed. According to the current text, if a UE reports (2,2), (4,3) and (7,3), then d\_span would be always $max\left(d\_{CORESET,max},2\right)$ as the minimum value of Y is 2. However, considering the following span pattern below, $Y\_{min}$ in this case should be 3 instead. Thus this should be clarified in the specification. **Proposal 2: When determining the duration of a span, Y\_min should be derived among applicable combinations of (X,Y) for the given SS set configurations to the UE.**  |

From feature lead point of view, the current specification is correct which follows the definition in Rel-15 for span. In addition, the example given in the figure above, it can be result in a 3 symbol duration due to the CORESET configuration.

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