**3GPP TSG RAN WG1 Meeting #105-E R1-210xxxx**

**e-Meeting, May 10th – 27th, 2021**

**Source: Moderator (Intel Corporation)**

**Title: Summary of discussion on PDSCH processing time per Capability 2 and DCI format 1\_0**

**Agenda item: 7.1**

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

# Introduction

This document summarizes the following discussion thread, relevant to Rel-15/16 NR specifications:

[105-e-NR-7.1CRs-01] Issue#5: PDSCH processing time per Capability 2 and DCI format 1\_0 – Debdeep (Intel) by May 25.

**~~Initial round of feedback expected latest by May 20~~~~th~~~~, 23:59 UTC.~~**

**~~Depending on the feedback to the first round of questions, further details and proposals to be considered further.~~**

**Please provide your feedback to the Moderator Proposals 1 and 2 in Section 3 latest by May 24th, 23:59 UTC.**

# DMRS for PDSCH scheduled by DCI 1\_0

As discussed in [1], the UE assumptions on DMRS for PDSCH are captured in Subclause 5.1.6.2 in TS 38.214 [2]. In particular, the following is described related to DMRS reception for PDSCH scheduled by DCI format 1\_0:

|  |
| --- |
| 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- For PDSCH with mapping type A and type B, the UE shall assume *dmrs-AdditionalPosition*='pos2' and up to two additional single-symbol DM-RS present in a slot according to the PDSCH duration indicated in the DCI as defined in Clause 7.4.1.1 of [4, TS 38.211], and- For PDSCH with allocation duration of 2 symbols with mapping type B, the UE shall assume that the PDSCH is present in the symbol carrying DM-RS. |

During the “preparation phase” of discussions preceding RAN1 #105-e meeting, different interpretations of the highlighted part of the sentence above have been shared within RAN1.

**Interpretation A:**

* The highlighted part corresponds to two conditions/scenarios:
	+ Scenario 1: “receiving PDSCH scheduled by DCI format 1\_0”
	+ Scenario 2: “receiving PDSCH before dedicated higher layer configuration of any of the parameters *dmrs-AdditionalPosition, maxLength* and *dmrs-Type*”

Following Interpretation A, Scenario 2 can be seen to include DCI format format 1\_1 in RRC connected mode when *dmrs-AdditionalPosition, maxLength* and *dmrs-Type* may not be configured. The behavior when these parameters may be configured to the UE is described in the following paragraph for DCI format 1\_1.

**Interpretation B:**

* The phrase “before dedicated higher layer configuration of any of the parameters *dmrs-AdditionalPosition, maxLength* and *dmrs-Type*” should also be applied to:
	+ “receiving PDSCH scheduled by DCI format 1\_0”, and
	+ “receiving PDSCH”

For Interpretation B above, if “before dedicated higher layer configuration of any of the parameters *dmrs-AdditionalPosition, maxLength* and *dmrs-Type*” applies to “receiving PDSCH scheduled by DCI format 1\_0” and “receiving PDSCH”, then the distinction/relevance of the two scenarios remain unclear. In other words, the first scenario “receiving PDSCH scheduled by DCI format 1\_0” becomes redundant to “receiving PDSCH”.

## Question 2.1

**Please indicate your interpretation of the highlighted statement below on UE behavior for PDSCH DMRS reception.**

|  |
| --- |
| 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- For PDSCH with mapping type A and type B, the UE shall assume *dmrs-AdditionalPosition*='pos2' and up to two additional single-symbol DM-RS present in a slot according to the PDSCH duration indicated in the DCI as defined in Clause 7.4.1.1 of [4, TS 38.211], and- For PDSCH with allocation duration of 2 symbols with mapping type B, the UE shall assume that the PDSCH is present in the symbol carrying DM-RS. |

* **Interpretation A:**
	+ The highlighted part corresponds to two conditions/scenarios:
		- Scenario 1: “receiving PDSCH scheduled by DCI format 1\_0”
		- Scenario 2: “receiving PDSCH before dedicated higher layer configuration of any of the parameters *dmrs-AdditionalPosition, maxLength* and *dmrs-Type*”
* **Interpretation B:**
	+ The phrase “before dedicated higher layer configuration of any of the parameters *dmrs-AdditionalPosition, maxLength* and *dmrs-Type*” should also be applied to:
		- “receiving PDSCH scheduled by DCI format 1\_0”
* **Other interpretation (kindly elaborate/justify)**

|  |  |  |
| --- | --- | --- |
| **Company** | **Interpretation** | **Comments** |
| Qualcomm | A |  |
| OPPO | A | We don’t know how it can be interpreted as Interpretation B. |
| Samsung | A |  |
| ZTE | A |  |
| vivo | A |  |
| DOCOMO | A |  |
| Ericsson | A |  |
| HW/HiSi | A |  |

Next, for the assumption *dmrs-AdditionalPosition*='pos2', for PDSCH with $l\_{d}$ greater than 7 symbols or 4 symbols for PDSCH mapping types A and B respectively, additional DMRS symbols beyond the first DMRS symbol indicated by $l\_{0}$ are assumed according to the above-quoted spec text from TS 38.214 on DMRS reception and Subclause 7.4.1.1 of TS 38.211 (see Table 1 below) [3]. Here, $l\_{d}$ (in symbols) corresponds to:

* duration between first symbol of a slot and last symbol of the PDSH for mapping type A, and
* duration between first and last symbol of the PDSCH for mapping type B, respectively.

Table 1: PDSCH DM-RS positions  for single-symbol DM-RS. [Table 7.4.1.1.2-3, TS 38.211, v16.5.0]

|  |  |
| --- | --- |
| $l\_{d}$ **in symbols** | **DM-RS positions**  |
| **PDSCH mapping type A** | **PDSCH mapping type B** |
| ***dmrs-AdditionalPosition*** | ***dmrs-AdditionalPosition*** |
| ***pos0*** | ***pos1*** | ***pos2*** | ***pos3*** | ***pos0*** | ***pos1*** | ***pos2*** | ***pos3*** |
| 2 | - | - | - | - |  |  | $$l\_{0}$$ | $$l\_{0}$$ |
| 3 |  |  |  |  | $$l\_{0}$$ | $$l\_{0}$$ | $$l\_{0}$$ | $$l\_{0}$$ |
| 4 |  |  |  |  |  |  | $$l\_{0}$$ | $$l\_{0}$$ |
| 5 |  |  |  |  | $$l\_{0}$$ | $$l\_{0},4$$ | $$l\_{0},4$$ | $$l\_{0},4$$ |
| 6 |  |  |  |  |  |  | $$l\_{0},4$$ | $$l\_{0},4$$ |
| 7 |  |  |  |  |  |  | $$l\_{0},4$$ | $$l\_{0},4$$ |
| 8 |  | , 7 | , 7 | , 7 | $$l\_{0}$$ | $$l\_{0}, 6$$ | $$l\_{0},3, 6$$ | $$l\_{0},3, 6$$ |
| 9 |  | , 7 | , 7 | , 7 | $$l\_{0}$$ | $$l\_{0},7$$ | $$l\_{0}, 4, 7$$ | $$l\_{0}, 4, 7$$ |
| 10 |  | , 9 | , 6, 9 | , 6, 9 | $$l\_{0}$$ | $$l\_{0}, 7$$ | $$l\_{0}, 4, 7$$ | $$l\_{0}, 4, 7$$ |
| 11 |  | , 9 | , 6, 9 | , 6, 9 | $$l\_{0}$$ | $$l\_{0}, 8$$ | $$l\_{0}, 4, 8$$ | $$l\_{0}, 3, 6, 9$$ |
| 12 |  | , 9 | , 6, 9 | , 5, 8, 11 | $$l\_{0}$$ | $$l\_{0},9$$ | $$l\_{0},5, 9$$ | $$l\_{0}, 3, 6, 9$$ |
| 13 |  | , $l\_{1}$ | , 7, 11 | , 5, 8, 11 | $$l\_{0}$$ | $$l\_{0},9$$ | $$l\_{0},5, 9$$ | $$l\_{0}, 3, 6, 9$$ |
| 14 |  | , $l\_{1}$ | , 7, 11 | , 5, 8, 11 | - | - | - | - |

## Question 2.2

**Please share your views on the following observation:**

* **According to Subclause 5.1.6.2 in TS 38.214 and Subclause 7.4.1.1 in TS 38.214,**
	+ **for PDSCH scheduled by DCI format 1\_0 with** $l\_{d}$ **greater than 7 symbols or 4 symbols for PDSCH mapping types A and B respectively, additional DMRS symbols are assumed beyond the first DMRS symbol indicated by** $l\_{0}$ **as reflected in Table 7.4.1.1.2-3, TS 38.211, v16.5.0.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree? (Y/N)** | **Comments** |
| Qualcomm | Y |  |
| OPPO | Y |  |
| Samsung | Y |  |
| ZTE | Y |  |
| vivo | Y |  |
| DOCOMO | Y |  |
| Ericsson  | Y |  |
| HW/HiSi | Y |  |

# Min UE processing times for PDSCH scheduled by DCI 1\_0 when UE is configured with Cap #2 in a DL cell

Next, we consider the conditions described in Tables 5.3-1 and 5.3-2 in Subclause 5.3 of TS 38.214 for applicability of Cap #1 timings (w/o and w/ additional DMRS) and Cap #2 processing times respectively.

We also, note that the following (from Subclause 5.3 of TS 38.214) indicates that Cap #2 timing applies in a cell only when the UE is configured with Cap #2 processing time for the DL serving cell via higher layers.

|  |
| --- |
| - For a UE that supports capability 2 on a given cell, the processing time according to UE processing capability 2 is applied if the high layer parameter *processingType2Enabled* in *PDSCH-ServingCellConfig* is configured for the cell and set to 'enable'. |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 5.3-1: PDSCH processing time for PDSCH processing capability 1

|  |  |
| --- | --- |
|  | PDSCH decoding time *N1* [symbols] |
| *dmrs-AdditionalPosition* = 'pos0' in *DMRS-DownlinkConfig* in both of *dmrs-DownlinkForPDSCH-MappingTypeA*, *dmrs-DownlinkForPDSCH-MappingTypeB* | *dmrs-AdditionalPosition* ≠ 'pos0' in *DMRS-DownlinkConfig* in either of *dmrs-DownlinkForPDSCH-MappingTypeA*, *dmrs-DownlinkForPDSCH-MappingTypeB* *or if the higher layer parameter is not configured*  |
| 0 | 8 | *N1,0 (= 13 or 14)* |
| 1 | 10 | 13 |
| 2 | 17 | 20 |
| 3 | 20 | 24 |

Table 5.3-2: PDSCH processing time for PDSCH processing capability 2

|  |  |
| --- | --- |
|  | PDSCH decoding time *N1* [symbols] |
| *dmrs-AdditionalPosition* = 'pos0' in *DMRS-DownlinkConfig* in both of *dmrs-DownlinkForPDSCH-MappingTypeA*, *dmrs-DownlinkForPDSCH-MappingTypeB* |
| 0 | 3 |
| 1 | 4.5 |
| 2 | 9 for frequency range 1 |

 |

Based on the above-quoted texts from the specifications, the following observations are tabled for discussion.

## Question 3.1

**Please indicate your views on the following summary of the logical flow of the current specifications:**

* **If** *processingType2Enabled* in *PDSCH-ServingCellConfig* is configured for the cell and set to 'enable',
	+ **If** *dmrs-AdditionalPosition = 'pos0'* in *DMRS-DownlinkConfig* in both of *dmrs-DownlinkForPDSCH-MappingTypeA, dmrs-DownlinkForPDSCH-MappingTypeB,*
		- **PDSCH processing time per Cap #2 applies;**
* **Else, if** *processingType2Enabled* in *PDSCH-ServingCellConfig* is NOT configured for the cell or configured by NOT set to 'enable',
	+ **If** *dmrs-AdditionalPosition = 'pos0'* in *DMRS-DownlinkConfig* in both of *dmrs-DownlinkForPDSCH-MappingTypeA, dmrs-DownlinkForPDSCH-MappingTypeB,*
		- **PDSCH processing time per Cap #1 without additional DMRS applies;**
	+ **Else, if** *dmrs-AdditionalPosition ≠ 'pos0'* in *DMRS-DownlinkConfig* in either of *dmrs-DownlinkForPDSCH-MappingTypeA, dmrs-DownlinkForPDSCH-MappingTypeB, or if the higher layer parameter is not configured,*
		- **PDSCH processing time per Cap #1 with additional DMRS applies.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree? (Y/N)** | **Comments** |
| Qualcomm | Y |  |
| OPPO | Y |  |
| Samsung | Y |  |
| ZTE | Y |  |
| vivo | Y |  |
| DOCOMO | Y |  |
| Ericsson | Y |  |
| Hw/HiSi | Y |  |

**Note:** Although the above seems to indicate that UE is expected to follow Cap #2 timing for all PDSCH as long as the first two conditions are satisfied, the UE assumption for PDSCH DMRS reception for PDSCH, scheduled by DCI format 1\_0 with *ld > 7* or *ld > 4* symbols for mapping types A or B respectively, remains unclear. This observation applies at least when assuming Interpretation A in response to Question 2.1 in Section 2.

In particular, a literal reading of the specifications indicate that UE should assume presence of additional DMRS as defined in Subclause 5.1.6.2 of TS 38.214 for a PDSCH scheduled by DCI format 1\_0 (assuming Interpretation A) while Subclause 5.3 of TS 38.214 suggests that UE is expected to follow Cap #2 timing for such a PDSCH if Cap #2 is configured by higher layers and . However, this should be clearly an infeasible combination for any reasonable UE implementation.

On the other hand, if the statement in Subclause 5.3 of TS 38.214 is expected to override the UE assumptions on PDSCH DMRS reception described in Section 2, when UE is configured with Cap #2 by higher layers, then this should be clarified as it is not clear otherwise which UE behavior from the same specification should take precedence. Further, details like assumptions on PDSCH RE mapping need to be clarified in this case – i.e., whether UE still assumes that PDSCH is NOT mapped to these symbols that would otherwise correspond to additional DMRS symbols or not (e.g., assumes PDSCH mapping is also like ‘pos0’), etc.

## Question 3.2

**Please indicate your views on the following:**

* **If** *processingType2Enabled* in *PDSCH-ServingCellConfig* is configured for the cell and set to ‘enable’, **and if** *dmrs-AdditionalPosition = ‘pos0’* in *DMRS-DownlinkConfig* in both of *dmrs-DownlinkForPDSCH-MappingTypeA, dmrs-DownlinkForPDSCH-MappingTypeB,* **then, for a PDSCH scheduled by DCI format 1\_0 with** *ld > 7* or *ld > 4* symbols for mapping types A or B respectively**, the one of the following for min UE processing times and DMRS assumptions respectively apply:**
	+ **Proc\_Time\_Alt 1: PDSCH processing time per Cap #2 applies**
	+ **Proc\_Time\_Alt 2: PDSCH processing time per Cap #1 with additional DMRS applies**
	+ **Proc\_Time\_Alt 3: PDSCH processing time per Cap #1 without additional DMRS applies**
	+ **DMRS\_Alt 1: PDSCH DMRS as per ‘pos2’ at least for PDSCH RE mapping but UE is not expected to process additional DMRS symbols for PDSCH reception (i.e. per ‘pos0’ for channel estimation for PDSCH reception)**
	+ **DMRS\_Alt 2: PDSCH DMRS as per ‘pos2’ for both PDSCH RE mapping and channel estimation for PDSCH reception**
	+ **DMRS\_Alt 3: PDSCH DMRS as per ‘pos0’ for both PDSCH RE mapping and channel estimation for PDSCH reception**
	+ **Other alternatives not precluded (please provide justification)**

***Note: Any combination of Proc\_Time alternatives and DMRS alternatives, including any new alternative not listed above, can be indicated with proper justification.***

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Proc\_Time Alt.** | **DMRS Alt.** | **Comments** |
| Qualcomm | Other | Alt.2 | As we mentioned in the preparation phase, there is no conflict between the following two that are clear from the spec.* For a DL cell configured with Cap#2, any PDSCH that requires UE to satisfy the PDSCH processing timeline shall be without additional DMRS.
* For PDSCH scheduled by DCI format 1\_0, additional DMRS on pos2 is assumed.

We do not think supporting dynamic fallback to Cap#1 is backward compatible change. |
| OPPO | Other | Alt.2 | It is clear from the spec. that for PDSCH scheduled by DCI format 1\_0, *dmrs-AdditionalPosition = ‘pos2’* should be assumed regardless of the RRC configuration. However, If*processingType2Enabled* is configured to be ‘enabled’, all the scheduled PDSCHs should not be configured with additional DMRS. In this case, we think PDSCH scheduled by DCI format 1\_0 is not expected by UE when *processingType2Enabled* is configured to be ‘enabled’. |
| Samsung | Alt 1 | Alt 2 | We share the similar view with Qualcomm.* If Capa#2 is configured, except 30 kHz SCS with many PRBs (>136) scheduled, the UE applies UE processing capability 2.
* N1/2 for Processing capability 2 is defined for “dmrs-AdditionalPosition = ‘pos0’ in DMRS-DownlinkConfig in both of dmrs-DownlinkForPDSCH-MappingTypeA, dmrs-DownlinkForPDSCH-MappingTypeB”. For PDSCH scheduled by DCI format 1\_0, additional DMRS on pos2 is assumed.
* When receiving PDSCH scheduled by DCI format 1\_0, the UE shall assume dmrs-AdditionalPosition=’pos2’ even when dmrs-AdditionalPosition = ‘pos0’ in DMRS-DownlinkConfig in both of dmrs-DownlinkForPDSCH-MappingTypeA, dmrs-DownlinkForPDSCH-MappingTypeB.

Fallback to Capa#1 in this case is an NBC change. |
| ZTE | Alt.2 | Alt.2 | In our view, the two bullets listed by Qualcomm clearly conflicts each other if Proc\_Time Alt 1 applies. If a UE cannot process PDSCH scheduled by DCI 1\_1 with Cap2 when additional DMRS is configured, we are not sure why the UE can magically process PDSCH scheduled by DCI 1\_0 with Cap2 when additional DMRS is configured (‘pos2’). On the other hand, as NW vendor, we would be ok if all UE vendors can do shorter processing for DCI 1\_0 if Cap2 is enabled (i.e., Proc\_Time Alt 1).  |
| Vivo | Alt.2 | Alt.2 | In our view, for PDSCH scheduled by DCI format 1\_0, *dmrs-AdditionalPosition = ‘pos2’* is always assumed. Thus, for *ld > 7* or *ld > 4* symbols for mapping types A or B respectively, PDSCH processing time per Cap #1 with additional DMRS applies.It seems that Proc\_Time\_Alt 2 and Proc\_Time\_Alt 3 are implementation related. We would like to hear more views. |
| DOCOMO | Other or Alt.1 | Alt.2 | In our understanding, there is no dynamic fallback to Cap#1 from Cap#2 other than the one for more than 136 PRBs with 30 kHz. However, it is not clear to us from the current spec whether PDSCH scheduled by DCI format 1\_0 can be scheduled if *processingType2Enabled* is configured to be ‘enabled’. There can be two interpretations; one is what OPPO mentions that PDSCH scheduled by DCI format 1\_0 is not expected since additional DMRS is not allowed when *processingType2Enabled* is configured to be ‘enabled’. The other is what Samsung comments that still PDSCH scheduled by DCI format 1\_0 can be scheduled with Cap#2 assuming dmrs-AdditionalPosition=’pos2’. We are fine with either of the interpretation as long as it is clarified or common understanding is made, while probably the first interpretation is preferred by some UE vendors. If the former is the common understanding, it would be better to add corresponding description to exclude the scheduling by DCI format 1\_0. Anyway, we would like to hear more views on it. |
| Ericssion | Alt 1 | Alt 2 | Share similar view as Samsung. |
| Spreadtrum |  | Alt 2 | We agree there is no fallback to Cap#1 for DCI 1\_0 in Rel-15. Thus, all the scheduling should be without additional DMRS. We support the solution provided by Qualcomm.  |
| HW/HiSi | Alt 2 | Alt 2 |  |

Based on the provided inputs above, the views can be summarized as in the table below.

|  |  |  |
| --- | --- | --- |
| **Option** | **UE behavior** | **Consequences** |
| **Option A** (QC, Oppo, Spreadtrum, DCM) | * For a UE configured with Cap #2 in a DL cell and NOT configured with additional DMRS by higher layers:
	+ ***All PDSCHs subject to HARQ-ACK feedback (“unicast PDSCHs”) that may be scheduled in the DL cell are expected to satisfy conditions for Cap #2 timeline (i.e., w/o additional DMRS)***
	+ For a PDSCH scheduled by DCI 1\_0 and subject to HARQ-ACK feedback, DMRS\_Alt 2 (PDSCH DMRS as per ‘pos2’ for both PDSCH RE mapping and channel estimation for PDSCH reception) applies
 | * For a UE configured with Cap #2 in a DL cell and NOT configured with additional DMRS by higher layers:
	+ The UE does not expect to be scheduled with PDSCH by DCI format 1\_0 with *ld > 7* or *ld > 4* symbols for mapping types A or B respectively in the cell
	+ **No NBC issue \*\***
	+ **Severe scheduling constraint since PDSCH longer than 7 symbols and 4 symbols for mapping types A and B respectively cannot be supported with DCI 1\_0**
 |
| **Option B** (SS, Ericsson, DCM, ZTE *(can accept if feasible for UE)*) | * For a UE configured with Cap #2 in a DL cell and NOT configured with additional DMRS by higher layers:
	+ ***For all PDSCHs, including PDSCH scheduled by DCI format 1\_0 with ld > 7 or ld > 4 symbols for mapping types A or B respectively, subject to HARQ-ACK feedback (“unicast PDSCHs”) are to follow Cap #2 timeline***
	+ For a PDSCH scheduled by DCI 1\_0 and subject to HARQ-ACK feedback, DMRS\_Alt 2 (PDSCH DMRS as per ‘pos2’ for both PDSCH RE mapping and channel estimation for PDSCH reception) applies
 | * For a UE configured with Cap #2 in a DL cell and NOT configured with additional DMRS by higher layers:
	+ The UE is expected to satisfy Cap #2 processing times as per Table 5.3-2, regardless of the PDSCH actually containing additional DMRS that the UE is expected to process
	+ **No NBC issue \*\***
	+ **Serious feasibility issue at the UE for Cap #2**
 |
| **Option C** (ZTE, vivo, HwHiSi) | * For a UE configured with Cap #2 in a DL cell and NOT configured with additional DMRS by higher layers:
	+ ***For a PDSCH scheduled by DCI format 1\_0 with ld > 7 or ld > 4 symbols for mapping types A or B respectively, subject to HARQ-ACK feedback (“unicast PDSCH”), the UE may fall back to Cap #1 timeline; other PDSCHs are to follow Cap #2 timeline, subject to any other applicable constraints (e.g., Cap 2 with 136 PRBs constraint for 30 kHz)***
	+ For a PDSCH scheduled by DCI 1\_0 and subject to HARQ-ACK feedback, DMRS\_Alt 2 (PDSCH DMRS as per ‘pos2’ for both PDSCH RE mapping and channel estimation for PDSCH reception) applies
 | * For a UE configured with Cap #2 in a DL cell and NOT configured with additional DMRS by higher layers:
	+ All PDSCH durations can be scheduled by DCI format 1\_0 for unicast PDSCH
	+ **This option is NBC to Rel-15 specs**
	+ **Feasibility issue for UE implementation due to overlapping of processing timelines in case a “fast PDSCH” follows a “slow PDSCH” in quick succession**
 |

***\*\* Note: Only one of Options A or B can be Backward Compatible (BC), depending on particular interpretation of the specs, but both options cannot simultaneously be BC.***

From the above summary in Table above, it can be observed that while Option A is the attractive from perspectives of backward compatibility and UE implementation, it poses some serious scheduling constraints.

* Unicast PDSCH by DCI 1\_0 are quite relevant for carrying RRC reconfiguration messages
* This also means that a gNB cannot use DCI 1\_0 for scheduling unicast PDSCH to carry URLLC-type traffic with PDSCH durations longer than 7 or 4 symbols for mapping types A or B respectively, which can be a handicap in terms of DCI format size optimization if the UE or gNB do not support DCI formats 0\_2/1\_2 since typically DCI formats 0\_1/1\_1 are much larger than DCI formats 0\_0/1\_0

On the other hand, Option B does not have scheduling constraints but feasibility for this option is not clear at all – a UE needs to be over-dimensioned significantly if it needs to support Cap #2 even when processing additional DMRS symbols for channel estimation for PDSCH.

To address the feasibility aspect, a modified Option B, Option B1 may be considered where the DMRS processing requirements are relaxed:

|  |  |  |
| --- | --- | --- |
| **Option B1** | * For a UE configured with Cap #2 in a DL cell and NOT configured with additional DMRS by higher layers:
	+ ***For all PDSCHs, including PDSCH scheduled by DCI format 1\_0 with ld > 7 or ld > 4 symbols for mapping types A or B respectively, subject to HARQ-ACK feedback (“unicast PDSCHs”) are to follow Cap #2 timeline***
	+ For PDSCH scheduled by DCI 1\_0 and subject to HARQ-ACK feedback, DMRS\_Alt 1 (PDSCH DMRS as per ‘pos2’ for PDSCH RE mapping but UE is not expected to process additional DMRS symbols for PDSCH reception) applies
 | * For a UE configured with Cap #2 in a DL cell and NOT configured with additional DMRS by higher layers:
	+ The UE is expected to satisfy Cap #2 processing times as per Table 5.3-2, regardless of the PDSCH actually containing additional DMRS or not
	+ The UE is NOT expected to process any additional DMRS
	+ Existing DMRS mapping and rules are maintained
	+ **No feasibility issue for UE implementation**
	+ **UE needs different handling of additional DMRS symbols in general for DMRS per ‘pos2’**
	+ **This option is NBC to Rel-15 specs**
 |
| **Option B2** | * For a UE configured with Cap #2 in a DL cell and NOT configured with additional DMRS by higher layers:
	+ ***For all PDSCHs, including PDSCH scheduled by DCI format 1\_0 with ld > 7 or ld > 4 symbols for mapping types A or B respectively, subject to HARQ-ACK feedback (“unicast PDSCHs”) are to follow Cap #2 timeline***
	+ For PDSCH scheduled by DCI 1\_0 and subject to HARQ-ACK feedback, DMRS\_Alt 3 (PDSCH DMRS as per ‘pos0’ for both PDSCH RE mapping and channel estimation for PDSCH reception) applies
 | * For a UE configured with Cap #2 in a DL cell and NOT configured with additional DMRS by higher layers:
	+ The UE is expected to satisfy Cap #2 processing times as per Table 5.3-2, regardless of the PDSCH actually containing additional DMRS or not
	+ The UE is NOT expected to process any additional DMRS
	+ **DMRS mapping rule is updated – if Cap #2 is configured and additional DMRS is not configured, then UE assumes DMRS per ‘pos0’ for PDSCH scheduled by DCI 1\_0 subject to HARQ-ACK feedback**
	+ **No feasibility issue for UE implementation**
	+ **No need for different handling of additional DMRS symbols for a given DMRS time domain configuration**
	+ **This option is NBC to Rel-15 specs**
 |

Considering the above options and their impact, it may be reasonable to assume Option A for Rel-15 specifications due to NBC considerations. Options B and C have serious feasibility issues at the UE side that lend them not so practical.

On the other hand, the severe scheduling limitation of Option A should be avoided for Rel-16. Towards this, either Options B1 or B2 can be considered for Rel-16.

Also, for Option C, some further handling to avoid overlapping processing timelines in case of fallback to Cap #1 timing, e.g., similar to the case of Cap 2 limited to 136 PRBs for 30 kHz case, would be necessary to make the solution feasible for pipelined UE architecture.

## Moderator Proposal 1

* ***Conclusion:*** *For Rel-15 specifications,*
	+ *For a UE configured with Cap #2 in a DL cell and NOT configured with additional DMRS by higher layers:*
		- *All PDSCHs subject to HARQ-ACK feedback (“unicast PDSCHs”) that may be scheduled in the DL cell are expected to satisfy conditions for Cap #2 timeline (i.e., w/o additional DMRS)*
		- *For a PDSCH scheduled by DCI 1\_0 and subject to HARQ-ACK feedback, DMRS\_Alt 2 (PDSCH DMRS as per ‘pos2’ for both PDSCH RE mapping and channel estimation for PDSCH reception) applies*
		- *The UE does not expect to be scheduled with PDSCH, that is subject to HARQ-ACK feedback, by DCI format 1\_0 with ld > 7 or ld > 4 symbols for mapping types A or B respectively in the cell.*

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree? (Y/N)** | **Comments** |
| Qualcomm | N | We do not think a conclusion is necessary since the following are already clear. Making a new conclusion, even if it is intended to re-state the spec, may have a risk of misalignment/NBC with the existing specs.* *For a UE that supports capability 2 on a given cell, the processing time according to UE processing capability 2 is applied based on Table 5.3-2 if the high layer parameter processingType2Enabled in PDSCH-ServingCellConfig is configured for the cell and set to ‘enable’*
	+ *In Table 5.3-2, PDSCH decoding time N1 for UE processing capability 2 is specified for “dmrs-AdditionalPosition = ‘pos0’ in DMRS-DownlinkConfig in both of dmrs-DownlinkForPDSCH-MappingTypeA, 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, …*
	+ *For PDSCH with mapping type A and type B, the UE shall assume dmrs-AdditionalPosition=’pos2’ and up to two additional single-symbol DM-RS present in a slot according to the PDSCH duration indicated in the DCI as defined in Clause 7.4.1.1 of [4, TS 38.211]*
 |
| Moderator |  | Updated above with the modification of the last sub-bullet in red as:* + - *The UE does not expect to be scheduled with PDSCH, that is subject to HARQ-ACK feedback, by DCI format 1\_0 with ld > 7 or ld > 4 symbols for mapping types A or B respectively in the cell.*
 |
| ZTE | N | There is no way for us to accept this proposal. This causes huge scheduling restriction for us.  |
| HW/HiSi | N | Similar to QC, we prefer to not make a conclusion for Rel-15.From companies’ responses it is clear that there are multiple interpretations of the specification. If a conclusion shall be made, maybe should simply state that fact, for example like that:. Proposed Conclusion: *For Rel-15 specifications,** + *For a UE configured with Cap #2 in a DL cell and NOT configured with additional DMRS by higher layers, there are different interpretation aligned with the specification:*
		- *Option A*
		- *Option B*
		- *Option C*
 |
| vivo | N | We also worry about the potential huge restriction.  |
| Ericsson | N | This has NBC implications. We need further checking internally with implementation and UE vendor channels. We can revisit this issue on next meeting if needed. |
| Nokia | N | This is obviously not OK, there is no such case why the spec would be limited in the PDSCH allocation duration with DCI format 1\_0. |

## Moderator Proposal 2

* *For Rel-16 specifications,*
	+ *For a UE configured with Cap #2 in a DL cell and NOT configured with additional DMRS by higher layers, one of the following Options is supported:*
		- *Option A*
		- *Option B*
		- *Option B1*
		- *Option B2*
		- *Option C*
		- *Other option (please elaborate)*

Note: Need for any spec update depends on choice above for Rel-16 and decision for Rel-15.

|  |  |  |
| --- | --- | --- |
| **Company** | **Preferred Option**  | **Comments** |
| Qualcomm | None | We do not think there are options for Rel-16 since the spec is clear. Any changes are beyond maintenance and could rather be new features that may require corresponding UE capabilities and RRC configurations. |
| ZTE |  | We are fine with Option B and C, while it seems they are also NBC for some companies. In such case, we can leave this issue for UE implementation. For instance, a UE can choose between Option B or Option B1 based on its capability of processing PDSCH (with additional DMRS) by Cap#2 in the concerned case, or a UE may not provide a valid HARQ-ACK corresponding to the scheduled PDSCH based on the following specification.*Otherwise the UE may not provide a valid HARQ-ACK corresponding to the scheduled PDSCH. The value of Tproc,1 is used both in the case of normal and extended cyclic prefix.*  |
| HW/HiSi | C | For Option C, we would like to discuss the consequences outlined by the FL in the summary. Why should it be NBC, could this be elaborated? In our view, the different views from companies show different but probably all somehow justified interpretation of the current spec.Regarding the implementation complexity, we don’t think that there should be a concern if Option C is followed and we don’t see a relationship to the optional scheduling restriction of 136 PRBs that were mentioned in the summary above. |
| vivo | C | In our view, Option C is BC.According to our understanding, the processing time for a PDSCH with front-loaded and non-front-loaded DMRS is generally different. From this perspective, a PDSCH with DMRS with ‘pos2’ should use Capabitlity#1 processing time because there is explicit processing time definition for *dmrs-AdditionalPosition ≠ 'pos0'* case in spec. Thus, a PDSCH scheduled by a DCI format 1\_0, Capability #1 is assumed even if *processingType2Enabled* is set to *‘enable’* on the cell.  |
| Ericsson | B, B1, C | For DCI 1\_0 how fast it can be processed is not an essential issue, its more important UE can handle same PDSCH combination as is used for cap#1 and there’s no ambiguity on mapping. |
| Nokia | B, B1, C | Agrree with Ericsson’s view, C would be in the spirit of the original intention. The fact that the DCI format 1\_0 has fixed DMRS-AdditionalPosition = Pos2 was not properly accounted for when the DMRS condition was defined. The condition should be about what is used, not what was configured. |

# Summary of discussion

*To be updated*

# References

1. R1-2105964, “PDSCH processing time per Capability 2 and DCI format 1\_0,” Intel Corporation, RAN1 #105-e.
2. 3GPP TS 38.214, v16.5.0.
3. 3GPP TS 38.211, v16.5.0.