**3GPP TSG RAN WG1 #117 R1-2405345**

**Fukuoka City, Fukuoka, Japan, May 20th – 25th, 2024**

**Source: Moderator (OPPO)**

**Title: Summary on Rel-18 STxMP**

**Agenda Item: 8.1**

**Document for: Discussion and Decision**

# Introduction

This document summarizes draft CRs on Rel-18 STxMP proposed in company contributions of AI 8.1.

# Draft CRs

## **PUSCH out-of-order in mDCI-based STxMP PUSCH+PUSCH**

In R1-2404096/ R1-2404095, Samsung proposed draft CR for 38.214 to clarify the UE behaviour of PUSCH out-of-order in mDCI based STxMP PUSCH+PUSCH. The reason is that in rel-18, we introduced UE FG 40-6-6 out-of-order for multi-DCI based STx2P PUSCH+PUSCH. And Samsung proposed the following draft CR for 38.214 to clarify related UE behavior:

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| 6.1 UE procedure for transmitting the physical uplink shared channel  < Unchanged parts are omitted >  Except for the case when a UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet* for the active BWP of a serving cell and PDCCHs that schedule two non-overlapping in time domain PUSCHs are associated to different *ControlResourceSets* having different values of *coresetPoolIndex* and the UE reports its capability of *outOfOrderOperationUL-r16,* for any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start a first PUSCH transmission starting in symbol *j* by a PDCCH ending in symbol *i*, the UE is not expected to be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH that ends later than symbol *i*.  < Unchanged parts are omitted >  If a UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet* for the active BWP of a serving cell and PDCCHs that schedule two non-overlapping in time domain PUSCHs are associated to different *ControlResourceSets* having different values of *coresetPoolIndex* and the UE reports its capability of *outOfOrderOperationUL-r16,* for any two HARQ process IDs in a given scheduled cell, if the UE is not configured with *sTx-2Panel* and is scheduled to start a first PUSCH transmission starting in symbol *j* by a PDCCH associated with a value of *coresetPoolIndex* ending in symbol *i*, the UE can be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH associated with a different value of *coresetPoolIndex* that ends later than symbol *i*.  If a UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet* for the active BWP of a serving cell and PDCCHs that schedule two PUSCHs are associated to different *ControlResourceSets* having different values of *coresetPoolIndex* and the UE is configured with *sTx-2Panel,* for any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start a first PUSCH transmission starting in symbol *j* by a PDCCH associated with a value of *coresetPoolIndex* ending in symbol *i*   * if the UE reports its capability of [*outOfOrderOperationUL-r18*],   + the UE can be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH associated with a different value of *coresetPoolIndex* that ends later than symbol *i*. * Otherwise,   + the UE is not expected to be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH associated with a different value of *coresetPoolIndex* that ends later than symbol *i*. |

**Proposal 1:** Adopt the above text proposal for TS 38.214

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| **Company** | **Comments** |
| Mod00 | Please share your views on this TP |
| QC | Not support the TP. Capturing UE capabilities / FGs with “if / otherwise” conditions in RAN1 spec will be redundant in general given that the FGs and their descriptions are already captured in 38.306. Otherwise, many more changes would be needed. Even for “multi-DCI” itself, there are various FGs (Rel-16 version, CB/NCB for Rel-18, different overlapping types, etc.). We do not think it is appropriate to start implementing UE feature list in 38.214 as long as description in 38.306 is clear. |
| Google | OK. This is a good clarification. |
| ZTE | We are supportive of capturing this UE capability for readability. Nevertheless, we think this TP can be simplified as follows, where the first part is used for Rel-16/18 OOO based MDCI MTRP PUSCH+PUSCH scheme and the second part is used for other cases.   |  | | --- | | 6.1 UE procedure for transmitting the physical uplink shared channel  < Unchanged parts are omitted >  Except for the case when a UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet* for the active BWP of a serving cell and PDCCHs that schedule two ~~non-overlapping in time domain~~ PUSCHs are associated to different *ControlResourceSets* having different values of *coresetPoolIndex* and the UE reports its capability of *outOfOrderOperationUL-r16* or *outOfOrderOperationUL-r18,* for any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start a first PUSCH transmission starting in symbol *j* by a PDCCH ending in symbol *i*, the UE is not expected to be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH that ends later than symbol *i*.  < Unchanged parts are omitted >  If a UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet* for the active BWP of a serving cell and PDCCHs that schedule two ~~non-overlapping in time domain~~ PUSCHs are associated to different *ControlResourceSets* having different values of *coresetPoolIndex* and the UE reports its capability of *outOfOrderOperationUL-r16* or *outOfOrderOperationUL-r18,* for any two HARQ process IDs in a given scheduled cell, if the UE ~~is not configured with~~ *~~sTx-2Panel~~* ~~and~~ is scheduled to start a first PUSCH transmission starting in symbol *j* by a PDCCH associated with a value of *coresetPoolIndex* ending in symbol *i*, the UE can be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH associated with a different value of *coresetPoolIndex* that ends later than symbol *i*.  ~~If a UE is configured by higher layer parameter~~ *~~PDCCH-Config~~* ~~that contains two different values of~~ *~~coresetPoolIndex~~* ~~in~~ *~~ControlResourceSet~~* ~~for the active BWP of a serving cell and PDCCHs that schedule two PUSCHs are associated to different~~ *~~ControlResourceSets~~* ~~having different values of~~ *~~coresetPoolIndex~~* ~~and the UE is configured with~~ *~~sTx-2Panel,~~* ~~for any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start a first PUSCH transmission starting in symbol~~ *~~j~~* ~~by a PDCCH associated with a value of~~ *~~coresetPoolIndex~~* ~~ending in symbol~~ *~~i~~*   * ~~if the UE reports its capability of [~~*~~outOfOrderOperationUL-r18~~*~~],~~   + ~~the UE can be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH associated with a different value of~~ *~~coresetPoolIndex~~* ~~that ends later than symbol~~ *~~i~~*~~.~~ * ~~Otherwise,~~   ~~the UE is not expected to be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH associated with a different value of~~ *~~coresetPoolIndex~~* ~~that ends later than symbol~~ *~~i~~*~~.~~ | |
| Samsung | Support. The reason why we would like to clarify this in RAN1 specification by using UE capability is that there is no dedicated RRC for out-of-order operation, even though this is an optional UE feature, not included in a basic feature of STx2P. Similarly, in TS38.214, there are many parts using UE capabilities only, but no dedicated RRC, especially in Clause 5.1.5.  After further checking in TS38.306-i10, and the UE capability for out-of-order operation for STx2P is “*twoPUSCH-MultiDCI-STx2P-OutOfOrder-r18*”. Hence, on top of our TP, the UE capability name can be revised. |
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## **UCI multiplexing**

Google proposed draft CR on UCI multiplexing for 38.213 in R1-2404681 along with the discussion paper R1-2404680 to clarify that one legacy behavior of UCI multiplexing “UE should always multiplex the UCI on the DG-PUSCH for DG-PUSCH+CG-PUSCH” is not applicable to STxMP PUSCHs case.

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| 9 UE procedure for reporting control information  <omitted text>  The UE determines the PUSCH for UCI multiplexing by applying the following procedure on the candidate PUSCHs as described in this clause:  - If the UE is provided *sTx-2Panel*, is provided *ackNackFeedbackMode* = *separate*, and would multiplex UCI that includes HARQ-ACK information in a PUSCH, candidate PUSCHs for the UCI multiplexing are the ones associated with same *coresetPoolIndex* value as for a PUCCH transmission with the HARQ-ACK information.  - If the UE is not provided *sTx-2Panel* or the UE is provided *sTx-2Panel* and the candidate PUSCHs are associated with the same *coresetPoolIndex*, the candidate PUSCHs that include first PUSCHs that are scheduled by DCI formats and second PUSCHs configured by respective *ConfiguredGrantConfig* or *semiPersistentOnPUSCH*, the UE would multiplex UCI in one of the candidate PUSCHs, and the candidate PUSCHs fulfil the conditions in clause 9.2.5 for UCI multiplexing, the UE multiplexes the UCI in a PUSCH from the first PUSCHs.  - If the UE would multiplex UCI in one of the candidate PUSCHs and the UE does not multiplex aperiodic CSI in any of the candidate PUSCHs, the UE multiplexes the UCI in a PUSCH of the serving cell with the smallest *ServCellIndex* subject to the conditions in clause 9.2.5 for UCI multiplexing being fulfilled. If the UE transmits more than one PUSCHs in the slot on the serving cell with the smallest *ServCellIndex* that fulfil the conditions in clause 9.2.5 for UCI multiplexing, the UE multiplexes the UCI in the earliest PUSCH that the UE transmits in the slot. If the UE is provided *sTx-2Panel*, is provided *ackNackFeedbackMode* = *joint* or the UCI does not include HARQ-ACK information, and the UE would transmit two PUSCHs in the slot that start at a same symbol on the serving cell with smallest *ServCellIndex* and fulfil the conditions in clause 9.2.5 for UCI multiplexing, the UE multiplexes the UCI in the PUSCH from the two PUSCHs associated with CORESETs that the UE is not provided *coresetPoolIndex* or is provided *coresetPoolIndex* with a value of 0. |

Mod: I took the liberty to update the RRC parameter name *enableSTx2PofmDCI*  to the latest name in 38.331.

**Proposal 2:** Adopt the above text proposal for TS 38.213

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| **Company** | **Comments** |
| Mod00 | Please share your views on this TP |
| QC | The RRC name change is ok. However, it seems other changes are not necessary. Specifically, prioritizing DG over CG is still applicable for “*ackNackFeedbackMode* = *joint*” based on legacy text. For “*ackNackFeedbackMode* = *separate*”, the first bullet already clarifies that the “candidate PUSCHs”. |
| Google | To clarify the motivation for the change in the second sub-bullet, the second paragraph is the R17 spec, which should be first clarified that it is applied for PUSCHs associated with the same CORESETPoolIndex, according to the following agreement.  **Agreement**  When multi-DCI based STxMP PUSCH+PUSCH is configured,   * the existing rules for resolving overlapping PUSCH for the cases of one PUSCH overlapping with another PUSCH in time in one serving cell specified in legacy specifications are performed separately for each coresetPoolIndex value.   Secondly, it should also be applied when STxMP is not configured, since this is R17 behavior. That’s why the conditions are proposed.  This is just to capture the existing agreement. There is nothing else. |
| ZTE | Tend to share QC’s understanding of the current spec. |
| Samsung | We are fine with this TP and same view with Google. In Rel-16, when multi-DCI multi-TRP is configured, although there is a corresponding *coresetPoolIndex* for DG PUSCH, but not for CG PUSCH. In Rel-18, we introduced a corresponding *coresetPoolIndex* for CG PUSCH as well, so this is a good clarification to support STx2P between DG + CG PUSCH with different *coresetPoolIndexes*, and maintain legacy multiplexing rule between DG + CG PUSCH with same *coresetPoolIndex*. |
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## **Clarify the precoding behavior of SDM/SFN in 38.211**

ZTE proposed draft CR to clarify precoding behavior of SDM/SFN in 38.211 in R1-2404709 along with the discussion paper R1-2404708. The proposed change for 38.211 is:

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| 6.3.1.5 Precoding  The block of vectors shall be precoded according to  where , . The set of antenna ports shall be determined according to the procedure in [6, TS 38.214].  - When the higher layer parameter *multipanelScheme* is set to 'SDMScheme', and if codepoint "10" of of *SRS Resource Set* *indicator* is indicated, the block of vectors shall be precoded by the precoder indicated by the first TPMI and the block of vectors shall be precoded by the precoder indicated by the second TPMI according to the procedure in [6, TS 38.214];  - When the higher layer parameter *multipanelScheme* is set to 'SFNScheme', and if codepoint "10" of of *SRS Resource Set* *indicator* is indicated, the block of vector shall be precoded by the precoder indicated by the first TPMI and the precoder indicated by the second TPMI separately according to the procedure in [6, TS 38.214].  For non-codebook-based transmission, the precoding matrix equals the identity matrix.  For codebook-based transmission, the precoding matrix depends on the number of antenna ports used for the transmission:  - for single-layer transmission on a single antenna port, ;  - for transmissions using 2, or 4 antenna ports, is given by Tables 6.3.1.5-1 to 6.3.1.5-7;  - for transmissions using 8 antenna ports, is given by  where  - the subscripts and denote the row of the respective matrix;  - is given by Table 6.3.1.5-8;  - the intermediate precoding matrix is given by Tables 6.3.1.5-9 to 6.3.1.5-24, 6.3.1.5-29 to 6.3.1.5-36, and 6.3.1.5-39 to 6.3.1.5-47 with representing the all-zero matrix with rows and columns;  - the submatrices are given by Tables 6.3.1.5-25 to 6.3.1.5-28 and 6.3.1.5-37 to 6.3.1.5-38.  The TPMI index used in the tables above is obtained from the DCI scheduling the uplink transmission or the higher layer parameters according to the procedure in [6, TS 38.214].  When the higher-layer parameter *txConfig* is not configured, the precoding matrix .  <------------------------- **Irrelevant parts are omitted** -------------------------> |

**Proposal 3:** Adopt the above text proposal for TS 38.211

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| **Company** | **Comments** |
| Mod00 | Please share your views on this TP |
| QC | Not essential as discussed over multiple meetings. |
| Google | Agree with QC |
| ZTE | Support this TP.  As mentioned by FL, this TP is indeed to keep consistency of precoding determination for STxMP SDM/SFN between TS 38.211 and TS 38.214. Without this, it is ambiguous to derive precoding behavior of both sides in UE side and gNB side.  As elaborated in our tdoc R1-2404708, this TP does NOT change anything with regards to PUSCH precoder of STxMP SDM/SFN and also does NOT touch anything of PUSCH/SRS port re-indexing. We sincerely hope this can be clarified to avoid any misunderstandings. |
| Samsung | Support this TP and agree with ZTE. |
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## **Maximum number of simultaneous SRS resources across two NCB SRS sets**

ZTE proposed draft CR for 38.214 in R1-2404711 along with the discussion paper R1-2404710 to clarify that specify that for the maximum number of SRS resources across two SRS resource sets for NCB that can be transmitted simultaneously should be limited by the UE capability and they proposed the following change for 38,214:

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| 6.1.1.2 Non-Codebook based UL transmission  For non-codebook based transmission, PUSCH can be scheduled by DCI format 0\_0, DCI format 0\_1, DCI format 0\_2, DCI format 0\_3 or semi-statically configured to operate according to Clause 6.1.2.3. If this PUSCH is scheduled by DCI format 0\_1, DCI format 0\_2, DCI format 0\_3 or semi-statically configured to operate according to Clause 6.1.2.3, the UE can determine its PUSCH precoder(s) and transmission rank based on the SRI(s) when multiple SRS resources are configured, where the SRI(s) is given by one or two SRS resource indicator(s) in DCI according to clause 7.3.1.1.2 and 7.3.1.1.3 of [5, 38.212] for DCI format 0\_1 and DCI format 0\_2, or the SRI is given by one SRS resource indicator in DCI according to clause 7.3.1.1.4 of [5, 38.212] for DCI format 0\_3, or the SRI is given by *srs-ResourceIndicator* according to clause 6.1.2.3, or SRIs given by *srs-ResourceIndicator* and *srs-ResourceIndicator2* according to clause 6.1.2.3.. The *SRS-ResourceSet(s)* applicable for PUSCH scheduled by DCI format 0\_1 and DCI format 0\_2 are defined by the entries of the higher layer parameter *srs-ResourceSetToAddModList* and *srs-ResourceSetToAddModListDCI-0-2* in *SRS-config*, respectively. The UE shall use one or multiple SRS resources for SRS transmission, where, in one or two SRS resource set(s), the maximum number of SRS resources which can be configured to the UE for simultaneous transmission in the same symbol and the maximum number of SRS resources are UE capabilities. The SRS resources transmitted simultaneously occupy the same RBs. For a given CC, multiple SRS resources in a set with usage “nonCodebook” are not expected to be partially overlapped in time. Only one SRS port for each SRS resource is configured. Only one or two SRS resource sets can be configured in *srs-ResourceSetToAddModList* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'nonCodebook', and only one or two SRS resource sets can be configured in *srs-ResourceSetToAddModListDCI-0-2* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'nonCodebook'. When two SRS resource sets are configured in *srs-ResourceSetToAddModList* or *srs-ResourceSetToAddModListDCI-0-2* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'nonCodebook', SRIs are given by the DCI fields of two SRS resource indicators in clauses 7.3.1.1.2 and 7.3.1.1.3 of [5, TS 38.212] for DCI format 0\_1 and 0\_2 and the UE applies the indicated SRI(s) to one or more PUSCH repetitions according to the associated SRS resource set of a PUSCH repetition according to clause 6.1.2.1. When two SRS resource sets are configured in *srs-ResourceSetToAddModList* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'nonCodebook', SRI is given by the DCI field of one SRS resource indicator in clause 7.3.1.1.4 of [5, TS 38.212] for DCI format 0\_3 and the UE applies the indicated SRI to one or more PUSCH repetitions according to the first SRS resource set. The maximum number of SRS resources per SRS resource set that can be configured for non-codebook based uplink transmission is 1, 2, 4 or 8 depending on UE capability. Each of the indicated SRIs in slot *n* is associated with the most recent transmission of SRS resource(s) of associated SRS resource set identified by the SRI, where the SRS transmission is prior to the PDCCH carrying the SRI. When two SRS resource sets are configured in *srs-ResourceSetToAddModList* or *srs-ResourceSetToAddModListDCI-0-2* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'nonCodebook', the UE is not expected to be configured with different number of SRS resources in the two SRS resource sets.  <------------------------- **Irrelevant parts are omitted** -------------------------> |

**Proposal 4:** Adopt the above text proposal for TS 38.214

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| **Company** | **Comments** |
| Mod00 | Please share your views on this TP |
| QC | Not support. This was also discussed in the previous meeting, and we do not see a need for this TP. |
| Google | We are open to STxMP for SRS, but we need to fix all the aspects within the meeting. One of the most important aspects is the power scaling. In addition, we should preclude partial overlapping similar to SRS for NCB/BM. |
| ZTE | Support this TP.  As mentioned by FL, the intention of this TP is to avoid the error case that the maximum number of simultaneous SRS across two SRS sets for NCB PUSCH exceeds the current UE capability, i.e., up to 4. If without this TP, it may wrongly be up to 5-8, which can NOT be realized by gNB.  @Google, we can understand your intention for integrity. However, as we explained in the last meeting, we think it is the separate issue and should be proper to be discussed independently. |
| Samsung | We are open to discuss this issue. Before this CR, we think discussion on whether to support simultaneous SRS transmission in different SRS resource set is needed. |
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## **Clarify PUSCH+PUSCH is allowed only when mDCI STxMP is configured**

Ericsson proposed draft CR for 38.214 in R1-2404752 to clarify overlapping PUSCHs are allowed for mDCI mTRP when STxMP is configured. And the proposed changes are:

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| 6.1 UE procedure for transmitting the physical uplink shared channel  <Unchanged parts omitted>  When the UE is scheduled with multiple PUSCHs on a serving cell by a DCI, HARQ process ID indicated by this DCI applies to the first PUSCH not overlapping with a DL symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* if provided, or a symbol of an SS/PBCH block with index provided by *ssb-PositionsInBurst*, HARQ process ID is then incremented by 1 for each subsequent PUSCH(s) in the scheduled order, with modulo operation of *nrofHARQ-ProcessesForPUSCH* applied if *nrofHARQ-ProcessesForPUSCH* is provided, or with modulo operation of *nrofHARQ-ProcessesForPUSCH-r17* applied if *nrofHARQ-ProcessesForPUSCH-r17* is provided, or with modulo operation of 16 applied, otherwise. HARQ process ID is not incremented for PUSCH(s) not transmitted if at least one of the symbols indicated by the indexed row of the used resource allocation table in the slot overlaps with a DL symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* if provided, or a symbol of an SS/PBCH block with index provided by *ssb-PositionsInBurst*. Except for the case when the UE is configured with *sTx-2Panel,* for any HARQ process ID(s) in a given scheduled cell, the UE is not expected to transmit a PUSCH that overlaps in time with another PUSCH. Except for the case when a UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet* for the active BWP of a serving cell and PDCCHs that schedule two PUSCHs are associated to different *ControlResourceSets* having different values of *coresetPoolIndex,* for any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start a first PUSCH transmission starting in symbol *j* by a PDCCH ending in symbol *i* on a scheduling cell,, the UE is not expected to be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH that ends later than symbol *i* of the scheduling cell. When the PDCCH reception includes two PDCCH candidates from two respective search space sets, as described in clause 10.1 of [6, TS 38.213], for the purpose of determining the PDCCH ending in symbol *i*, the PDCCH candidate that ends later in time is used. The UE is not expected to be scheduled to transmit another PUSCH by a DCI format 0\_0 with CRC scrambled by TC-RNTI, for a given HARQ process with the DCI received before the end of the expected transmission of the last PUSCH for that HARQ process if the latter is scheduled by a DCI format 0\_0 with CRC scrambled by TC-RNTI or by an UL grant in RA Response. The UE is not expected to be scheduled to transmit another PUSCH by DCI format 0\_0, 0\_1, 0\_2 or 0\_3 scrambled by C-RNTI, CS-RNTI or MCS-C-RNTI for a given HARQ process with the DCI received before the end of the expected transmission of the last PUSCH for that HARQ process if the latter is scheduled by a DCI with CRC scrambled by C-RNTI, CS-RNTI or MCS-C-RNTI.  <Unchanged parts omitted> |

**Proposal 5:** Adopt the above text proposal for TS 38.214

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| **Company** | **Comments** |
| Mod00 | Please share your views on the TP |
| QC | Ok. |
| Google | The change could cause a potential issue for STxMP. For STxMP, it is important to preclude two PUSCHs scheduled by the same HARQ process ID. So, the exception should only be applied to two different HARQ process IDs case. For the same HARQ process ID case, the exception should still be defined. Therefore, we suggest the following modification on top of the CR.  Except for the case when the UE is configured with *sTx-2Panel,* for any HARQ process IDs~~(s)~~ in a given scheduled cell, the UE is not expected to transmit a PUSCH that overlaps in time with another PUSCH. The UE is not expected to transmit a PUSCH that overlaps in time with another PUSCH based on the same HARQ process ID in a given scheduled cell. |
| ZTE | Fine to this TP for alignment. Regarding the update suggested by Google, it seems redundant to this TP. More precisely, it is captured for the case of a single HARQ process ID in our understanding. |
| Samsung | We are fine with this TP. |
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# Proposals for Online Discussion

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