**3GPP TSG RAN WG1 #117 R1-24xxxxx**

**Fukuoka City, Fukuoka, Japan, May 20th – 24th, 2024**

**Agenda item:** 8.2.1

**Source:** Moderator (NTT DOCOMO, INC.)

**Title:** Summary of discussion on UE features for MC enhancements

**Document for:** Discussion and Decision

# **Introduction**

This document summarizes contributions submitted to AI 8.2.1 regarding UE features for MC enhancements.

According to the updated UE features list agreed in RAN1#116bis [1], there are following feature groups for MC enhancements.

* FGs for multi-cell PUSCH/PDSCH scheduling with a single DCI
  + 49-1 Multi-cell PDSCH scheduling by DCI format 1\_3 on a scheduling cell with same SCS between scheduling cell and cells in the set
  + 49-1b Multi-cell PDSCH scheduling by DCI format 1\_3 on a scheduling cell not included in a set of cells with different SCS/carrier type between scheduling cell and cells in the set
  + 49-2 Multi-cell PUSCH scheduling by DCI format 0\_3 on a scheduling cell with same SCS between scheduling cell and cells in the set
  + 49-2b Multi-cell PUSCH scheduling by DCI format 0\_3 on a scheduling cell not included in a set of cells with different SCS/carrier type between scheduling cell and cells in the set
  + 49-3x Advanced UE capability for larger number of unicast DL DCI
  + 49-3y Advanced UE capability for larger number of unicast UL DCI
  + 49-4a Nominal RBG size of Configuration 3 for FDRA type 0 for DCI format 1\_3
  + 49-4b Nominal RBG size of Configuration 3 for FDRA type 0 for DCI format 0\_3
  + 49-4c Configurable Type-1A fields for DCI format 0\_3/1\_3
  + 49-4d FDRA Type 1 granularity of 2, 4, 8, or 16 consecutive RBs based RIV for DCI format 1\_3/0\_3
  + 49-5a Trigger Type 3 HARQ CB based feedback using DCI format 1\_3
  + 49-5b Trigger enhanced Type 3 HARQ CB based feedback using DCI format 1\_3
  + 49-6 Two HARQ-ACK codebooks with up to one sub-slot based HARQ-ACK codebook simultaneously constructed for supporting HARQ-ACK codebooks with different priorities by DCI format 1\_3
  + 49-6a Two HARQ-ACK codebooks with two sub-slot based HARQ-ACK codebook simultaneously constructed for supporting HARQ-ACK codebooks with different priorities by DCI format 1\_3
  + 49-6b DL priority indication in DCI with mixed DCI formats including DCI format 1\_3
  + 49-7 UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels in physical layer for DCI format 1\_3/0\_3
  + 49-7a UL priority indication in DCI with mixed DCI formats including DCI format 0\_3
  + 49-8 Triggered HARQ-ACK codebook re-transmission for DCI format 1\_3
  + 49-9 SCell dormancy indication within active time in DCI format 0\_3/1\_3
  + 49-10 Dynamic indication of applicable minimum scheduling restriction by DCI format 0\_3/1\_3
* FGs for multi-carrier UL Tx switching scheme
  + 49-X Supported switching option for each band pair in the band combination for UL Tx switching across more than 2 bands
  + 49-Y Minimum separation time for two uplink switching on more than 2 bands within any two consecutive reference slots

# **FGs for multi-cell PUSCH/PDSCH scheduling with a single DCI**

Following inputs are provided in contributions for the RAN1#116 meeting.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| [2] | Huawei, HiSilicon | **Unified-TCI indication by DCI format 1\_3**  One remaining issue is to support unified TCI indication by DCI format 1\_3. As shown by FG 23-1-1b/ FG 23-10-1b, UE features defining the UE capabilities for unified TCI with joint and separate DL/UL TCI updates are supported in DCI format 1\_1/1\_2. It is preferable to introduce corresponding new FGs for DCI format 1\_3.  **Proposal 2: Support FG49-11 and FG49-12 to introduce unified-TCI indication for DCI format 1\_3 as in Appendix 2.**   |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 49-11 | Unified TCI with joint DL/UL TCI update by DCI format 1\_3 for intra- and inter-cell beam management with more than one MAC-CE activated joint TCI state per CC | 1. TCI state indication for update and activationby MAC-CE+DCI-based TCI state indication. 2. The minimum beam application time in Y symbols per SCS 3. The maximum number of MAC-CE activated joint TCI states per CC in a band | 23-1-1 |  |  |  | Per band |  |  |  | Component 2 candidate values: {1, 2, 4, 7, 14, 28, 42, 56, 70, 84, 98, 112, 224, 336}, where {84, 98, 112, 224, 336} only can be indicated in FR2  Component 3 candidate values: {2, 3, 4, 5, 6, 7, 8}  Note: The maximum number of MAC-CE activated joint TCI states across all CC(s) in a band for more than one MAC-CE activated joint TCI state is signaled in 23-1-1, component 5  Note: activated joint TCI state(s) include all PDCCH/PDSCH receptions and PUSCH/PUCCH | | 49-12 | Unified TCI with separate DL/UL TCI update by DCI format 1\_3 for intra-cell beam management with more than one MAC-CE activated separate TCI state per CC | 1. TCI state indication for update and activationby MAC-CE+DCI-based TCI state indication. 2. The minimum beam application time in Y symbols per SCS 3. The maximum number of MAC-CE activated DL TCI states per CC in a band 4. The maximum number of MAC-CE activated UL TCI states per CC in a band | 23-10-1 |  |  |  | Per band |  |  |  | If a UE supports FG 23-10-1m, the signalled component values also apply to inter-cell beam management |   **PHY priority handling for one-shot HARQ-ACK feedback triggered by DCI format 1\_3**  In RAN1#116bis meeting, a new capability FG49-6, was introduced for DCI format 1\_3. Consequently, FG25-5 cannot be reused for triggering one-shot HARQ-ACK feedback with different PHY priorities by DCI format 1\_3, because FG11-4 is one of the prerequisite features of FG25-5 and FG11-4 is used for legacy DCI.  **Proposal 3: Support FL Proposal 2-8 in [3].** |
| [3] | ZTE | In RAN1#116bis, the following FG was discussed.   |  |  |  | | --- | --- | --- | | **Index** | **Feature group** | **Components** | | 49-x | PHY priority handling for one-shot HARQ-ACK feedback triggered by DCI format 1\_3 | Support transmission of type 3 HARQ-ACK codebook using the first or second PUCCH configuration based on PHY priority indication in the triggering DCI format 1\_3 |   This feature group is copied from the legacy FG 25-5. It is used for the UE to indicate the support of the Type-3 HARQ-ACK codebook with PHY priority indicated by the DCI format 1\_3. If the UE does not support this FG, the consequence is that PHY priority indication cannot be included in the DCI format 1\_3 if the Type-3 codebook is configured for the UE. In other words, the gNB cannot configure that DCI format 1\_3 includes Priority indicator field and One-shot HARQ-ACK request field or Enhanced Type 3 codebook indicator field simultaneously. This FG is only about the PHY priority indication for Type-3 codebook. Therefore, FG name should be PHY priority indication for one-shot HARQ-ACK feedback triggered by DCI format 1\_3 since PHY priority handing includes more things, e.g., multiplexing for the same PHY priority, cancellation for the different PHY priorities, which have been covered by the other FGs. This FG is similar as the FG 49-6b and therefore the reporting type should be per UE without differentiation.  ***Proposal 1:*** *If the following FG is introduced, the FG name should be PHY priority indication for one-shot HARQ-ACK feedback triggered by DCI format 1\_3 and the reporting type should be per UE without differentiation.*   |  |  |  | | --- | --- | --- | | ***Index*** | ***Feature group*** | ***Components*** | | *49-x* | *PHY priority handling for one-shot HARQ-ACK feedback triggered by DCI format 1\_3* | *Support transmission of type 3 HARQ-ACK codebook using the first or second PUCCH configuration based on PHY priority indication in the triggering DCI format 1\_3* |   In the legacy, if the UE supports more than one BWPs, the UE should support BWP switching including DCI-based BWP switching and timer-based BWP switching. This is not relevant to the DCI formats. Therefore, there is no need to introduce feature group on DCI format 1\_3/0\_3 based BWP switching.  ***Proposal 2:*** *There should be no need to introduce feature group for DCI format 1\_3/0\_3 based BWP switching.* |
| [4] | Samsung | A remaining issue from RAN1#116bis is about the support of functionality and UE feature for unified TCI indication via DCI format 1\_3, as captured in the FL summary [1].   |  | | --- | | **FL Summary on UE features for MC enhancements [1]**  **(Pending) Proposal 2-13:**   * Clarify whether unified TCI indication by using DCI format 1\_3 is supported in maintenance discussion.   + If supported, introduce new FG for unified TCI indication by using DCI format 1\_3 |   The support of unified TCI state via DCI format 1\_3 along with PDSCH scheduling is already adopted in TS 38.214, as shown in the following excerpt. In fact, it is understood that most/all UE and gNB implementations since Rel-17 may only implement the Rel-17 unified TCI framework, so the UE feature list should be clear in supporting the unified TCI indication via DCI format 1\_3. Since the legacy FGs 23-1-1b and 23-10-1b for unified TCI indication explicitly mention the legacy SC-DCI formats, new FGs are needed to capture the functionality for MC-DCI.   |  | | --- | | **Excerpt from TS 38.214 v18.2.0 – Clause 5.1.5**  When *tci-PresentInDCI* is set as 'enabled' or *tci-PresentDCI-1-2* is configured for the CORESET, a UE configured with *dl-OrJointTCI-StateList* with activated *TCI-State* or *ul-TCI-StateList* with activated *TCI-UL-State* receives DCI format 1\_1/1\_2/1\_3 providing indicated *TCI-State(s)* and/or *TCI-UL-State(s)* for a CC or all CCs in the same CC list configured by *simultaneousU-TCI-UpdateList1-r17, simultaneousU-TCI-UpdateList2-r17, simultaneousU-TCI-UpdateList3-r17, simultaneousU-TCI-UpdateList4-r17*. …. |   It is noted that, for unified TCI indication, there is still an open issue whether DCI format 1\_3, similar to DCI format 1\_1, can indicate unified TCI without DL assignment or for non-scheduled cells in case of “partial” scheduling. This issue was briefly discussed in the MCE maintenance in RAN1#116bis [2], and is raised in the draft CR [3] for additional discussion and decision in RAN1#117. However, the latter issue has no impact on the main functionality of DCI format 1\_3 for indication of unified TCI state and the introduction of corresponding new UE features. Only a component (1c) can be left as FFS until a decision is made in the MCE maintenance session.  **Proposal 3:** The following new FGs 49-n and 49-na are introduced for unified TCI indication via DCI format 1\_3.   * The FFS for component (1c) to be resolved after corresponding discussion in the maintenance session.  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 49-n | Unified TCI with joint DL/UL TCI update for intra- and inter-cell beam management with more than one MAC-CE activated joint TCI state per CC for DCI format 1\_3 | 1. TCI state indication for update and activation b) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_3 with DL assignment) FFS c) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_3 without DL assignment)  2. The minimum beam application time in Y symbols per SCS  3. The maximum number of MAC-CE activated joint TCI states per CC in a band | 23-1-1, and at least one of {49-1, 49-1b} |  | *MIMO-ParametersPerBand* | n/a | n/a | n/a | Component 2 candidate values: {1, 2, 4, 7, 14, 28, 42, 56, 70, 84, 98, 112, 224, 336}, where {84, 98, 112, 224, 336} only can be indicated in FR2  Component 3 candidate values: {2, 3, 4, 5, 6, 7, 8}  Note: The maximum number of MAC-CE activated joint TCI states across all CC(s) in a band for more than one MAC-CE activated joint TCI state is signaled in 23-1-1, component 5  Note: activated joint TCI state(s) include all PDCCH/PDSCH receptions and PUSCH/PUCCH | Optional with capability signalling |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 49-na | Unified TCI with separate DL/UL TCI update for intra-cell beam management with more than one MAC-CE activated separate TCI state per CC for DCI format 1\_3 | 1. TCI state indication for update and activation  b) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_3 with DL assignment) FFS c) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_3 without DL assignment)  2. The minimum beam application time in Y symbols per SCS  3. The maximum number of MAC-CE activated DL TCI states per CC in a band  4. The maximum number of MAC-CE activated UL TCI states per CC in a band | 23-10-1, and at least one of {49-1, 49-1b} |  | *MIMO-ParametersPerBand* | n/a | n/a | n/a | If a UE supports FG 23-10-1m, the signalled component values also apply to inter-cell beam management | Optional with capability signalling | |
| [5] | Nokia | There has been very good progress during RAN1#116bis on additional required UE capabilities.  On the existing (agreed) UE features groups we would only like to suggest, that for the reporting of some candidate values of the newly added FGs if there is a ‘similar’ FG for the legacy, single cell DCI formats and there is a component reporting, the UE should indicate the same component values for DCI formats 0\_3/1\_3 as for the legacy single cell DCI formats. This would be aligned with the agreed note in yellow to the enh. Type 3 CB triggering in FG 49-5b, which looks as:   |  |  |  |  | | --- | --- | --- | --- | | 49-5b | Trigger enhanced Type 3 HARQ CB based feedback using DCI format 1\_3 | 1. Support feedback of enhanced type 3 HARQ-ACK codebook, triggered by a DCI 1\_3  2. Support configuration of up to 8 enhanced type 3 HARQ-ACK codebooks.  3. Support feedback of a dynamically selected enhanced type 3 HARQ-ACK codebook based on triggering information in DCI 1\_3  4. Support transmission of enhanced type 3 HARQ-ACK codebook using the first or second PUCCH configuration based on PHY priority indication in the triggering DCI (for a UE supporting two HARQ-ACK codebooks / PUCCH config in 49-6)  5. Supported maximum number of actual PUCCH transmissions for type 3 or enhanced type 3 HARQ-ACK codebook feedback within a slot | For component 2, the UE indicates its capability in the number of enhanced type 3 HARQ-ACK codebooks: {1, 2, 4, 8}  For component 3, the dynamic indication is only supported if the UE for component 2 supports more than one enhanced type 3 HARQ-ACK codebook to be configured  Candidate values for component 5 is: {1, 2, 3, 4, 5, 6, 7}.    For component 2 and 5, same values as for FG25-6 are reported (if the UE also report FG25-6) |   Accordingly, we suggest the following similar handling for the following FGs:   * 49-6: Candidate values of component 6 should be the same as in FG 11-4 (if the UE also reports 11-4)   + i.e. same maximum number of PUCCH transmissions with HARQ per slot should be reported * 49-6a: Candidate values of component 6 should be the same as in FG 11-4a (if the UE also reports 11-4a)   + i.e. same maximum number of PUCCH transmissions with HARQ per slot should be reported * 49-7: Candidate values of component 4 & 5 should be the same as in FG 12-1 (if the UE also reports 12-1)   + i.e. same additional PUSCH preparation and cancellation time should be reported * 49-8: Candidate values of component 3 & 4 should be the same as in FG 25-7 (if the UE also reports 25-7)   + i.e. same minimum and maximum value for the HARQ re-tx offset should be reported   **Proposal 2: To guarantee coherent UE reporting on some UE features for DCI formats 0\_3/1\_3 and the (single cell) legacy DCI formats, add the following related notes to FG 49-6, 49-6b, 49-7 and 49-8 (similar as the existing note to 49-5b).**   |  |  |  |  | | --- | --- | --- | --- | | 49-6 | Two HARQ-ACK codebooks with up to one sub-slot based HARQ-ACK codebook simultaneously constructed for supporting HARQ-ACK codebooks with different priorities by DCI format 1\_3 | 1.Supports two HARQ-ACK codebooks with different priorities to be simultaneously constructed with the restriction up to one sub-slot based HARQ-ACK codebook.  2.Supports separate PUCCH configuration for different HARQ-ACK codebooks.  3.Supports 2-level priority of HARQ-ACK for dynamically scheduled PDSCH and SPS PDSCH.  4.Supports a DCI format 1\_3 scheduling PDSCH with different HARQ-ACK priorities when only DCI format 0\_3/1\_3 is configured per BWP.  5.Supports separate configuration of parameters PDSCH-HARQ-ACK-Codebook, UCI-OnPUSCH and 'codeBlockGroupTransmission" for different HARQ-ACK codebooks.  6.Supported maximum number of actual PUCCH transmissions for HARQ-ACK within a slot   1. Candidate values for the component 6 of this FG is: For NCP, {4, 5, 6, 7} for 2-symbol\*7 sub-slot configuration; For ECP, the candidate value is {4,5,6} for 2-symbol\*6 sub-slot configuration  7.Support intra-UE multiplexing/prioritization of UL overlapping channels/signals with two priority levels for HARQ-ACK | If a UE reports both 11-3 and this FG, it can support two slot-based HARQ-ACK codebooks, and one slot-based and one-sub-slot-based HARQ-ACK codebooks. If a UE reports this FG but not 11-3, it can only support two slot-based HARQ-ACK codebooks.    The number of PUCCHs for CSI reporting per slot is not impacted compared with Rel-15 by introducing the new HARQ-ACK CBs    Component 6 is applied to the sub-slot HARQ-ACK codebook. It is assumed that only 1 actual PUCCH transmission for HARQ-ACK within a slot for slot-based HARQ-ACK codebook.   1. Component 6 is reported for 2-symbol\*7 sub-slot configuration. For 7-symbol\*2 sub-slot configuration, the value of component 6 is {2} for both NCP and ECP cases.   For component 6, maximum of 1 actual PUCCH transmission for HARQ-ACK within a slot for slot-based HARQ-ACK codebook. Thus value reported for component 6 has no meaning for "slot-based + slot based".  For component 6, same values as for FG11-4 are reported (if the UE also report FG11-4) | | 49-6a | Two HARQ-ACK codebooks with two sub-slot based HARQ-ACK codebook simultaneously constructed for supporting HARQ-ACK codebooks with different priorities by DCI format 1\_3 | 1.Supports two subslot based HARQ-ACK codebooks with different priorities to be simultaneously constructed.  2.Supports separate PUCCH configuration for different HARQ-ACK codebooks.  3.Supports 2-level priority of HARQ-ACK for dynamically scheduled PDSCH and SPS PDSCH.  4.Supports a DCI format 1\_3 scheduling PDSCH with different HARQ-ACK priorities when only DCI format 0\_3/1\_3 is configured in USS per BWP.  5.Supports separate configuration of parameters PDSCH-HARQ-ACK-Codebook, UCI-OnPUSCH and "codeBlockGroupTransmission" for different HARQ-ACK codebooks.  6.Supported maximum number of actual PUCCH transmissions for HARQ-ACK within a slot.   1. Candidate values for the component 6 of this FG is: For NCP, {4, 5, 6, 7} for 2-symbol\*7 sub-slot configuration; For ECP, the candidate value is {4,5,6} for 2-symbol\*6 sub-slot configuration. | The number of PUCCHs for CSI reporting per slot is not impacted compared with Rel-15 by introducing the new HARQ-ACK CBs    Component 6 is applied to the two sub-slot HARQ-ACK codebooks, respectively.    Component 6 is reported for 2-symbol\*7 sub-slot configuration. For 7-symbol\*2 sub-slot configuration, the value of component 6 is {2} for both NCP and ECP cases.  For component 6, same values as for FG11-4a are reported (if the UE also report FG11-4a) | | 49-7 | UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels in physical layer for DCI format 1\_3/0\_3 | Support intra-UE multiplexing/prioritization of overlapping PUCCH/PUCCH and PUCCH/PUSCH with two priority levels in physical layer (PHY) for DCI format 1\_3/0\_3  1)Configuration of PHY priority level for CG PUSCH and SR, and dynamic indication of priority level for dynamic PUSCH with a single DCI format 0\_3  2)Multiplexing/prioritization between UL channels/signals with the same PHY priority level  3)Prioritization between UL channels/signals with different PHY priority levels  4)Additional number of symbols (d1) needed beyond the PUSCH preparation time for cancelling a low priority UL transmission.  5)Additional number of symbols (d2) of the preparation time needed for the high priority UL transmission that cancels a low priority UL transmission | Candidate value set for component 4: {0, 1, 2}    Candidate value set for component 5: {0, 1, 2}  For component 4 and 5, same values as for FG12-1 are reported (if the UE also report FG12-1) | | 49-8 | Triggered HARQ-ACK codebook re-transmission for DCI format 1\_3 | 1. Support HARQ-ACK re-transmission from an earlier PUCCH slot based on the triggering information in DCI format 1\_3  2. Support the related PHY priority handling in terms of HARQ-ACK codebook selection and the applicable PUCCH configuration (for a UE supporting two HARQ-ACK codebooks / PUCCH config in 49-6)  3. Supported minimum value M for the HARQ re-tx offset  4. Supported maximum value N for the HARQ re-tx offset | Candidate values for component 3 is: M = {-7, -5, …, 1}    Candidate values for component 4 is: N= {4, 6, …, 24}    Note: The minimum requirement for Component 3 and Component 4 of this FG is valid for HARQ CBs consisted of HARQ Processes with a single HARQ bit per HARQ Process ID  For component 3 and 4, same values as for FG25-7 are reported (if the UE also report FG25-7) | |
| [6] | OPPO | RAN1 #116bis agreed the following new FG49-8 for HARQ-ACK re-transmission triggered by DCI 1\_3.   |  | | --- | | Agreement:   * Introduce new FG49-8 for HARQ-ACK re-transmission triggered by DCI format 1\_3 (based on 25-7)   + FG name:     - Triggered HARQ-ACK codebook re-transmission for DCI format 1\_3   + Component:     - 1. Support HARQ-ACK re-transmission from an earlier PUCCH slot based on the triggering information in DCI format 1\_3     - 2. Support the related PHY priority handling in terms of HARQ-ACK codebook selection and the applicable PUCCH configuration (for a UE supporting two HARQ-ACK codebooks / PUCCH config in 49-6)     - 3. Supported minimum value M for the HARQ re-tx offset     - 4. Supported maximum value N for the HARQ re-tx offset   + Prerequisite:     - 25-7 and at least one of {49-1, 49-1b}   + Type:     - Per band   + Note:     - Candidate values for component 3 is: M = {-7, -5, …, 1}     - Candidate values for component 4 is: N= {4, 6, …, 24}     - Note: The minimum requirement for Component 3 and Component 4 of this FG is valid for HARQ CBs consisted of HARQ Processes with a single HARQ bit per HARQ Process ID   + Mandatory or Optional:     - Optional with capability signaling |   This new FG49-8 is cloned from legacy FG25-7 by copying all FG components, Types and Note field of FG25-7 with necessary modifications as highlighted in the agreement. Then it is unnecessary and even misleading to take, at meanwhile, FG25-7 as a prerequisite of new FG49-8.  ***Proposal 1: Remove “25-7” from prerequisite of new FG49-8.*** |
| [7] | NTT DOCOMO, INC. | At the RAN1#116 meeting, UE features for MCE were discussed, and there are several remaining proposals in the moderator’s summary as shown below [3].   |  | | --- | | Proposal 2-8:   * Introduce new FG for PHY priority handling for one-shot HARQ-ACK feedback triggered by DCI format 1\_3   Proposal 2-13:   * Clarify whether unified TCI indication by using DCI format 1\_3 is supported in maintenance discussion.   + If supported, introduce new FG for unified TCI indication by using DCI format 1\_3   Proposal 2-14:   * Conclude that existing FGs for BWP switching are reused for DCI format 0\_3/1\_3   Proposal 2-15:   * Introduce new FG for support of 480/960 kHz SCS for multi-cell scheduling by DCI format 0\_3/1\_3 |  PHY priority handling for one-shot HARQ-ACK feedback According to the discussion at the RAN1#116bis meeting, it was pointed that the legacy FG for PHY priority handling for one-shot HARQ-ACK feedback is not DCI format specific, and hence it is not necessary to introduce new FG for DCI format 1\_3.  **Proposal 8: Conclude that the existing FGs for PHY priority handling for one-shot HARQ-ACK feedback is reused for DCI format 1\_3.** Unified TCI While some clarifications are still discussed in the maintenance session, we believe that unified TCI indication is supported by DCI format 1\_3 as well as legacy DCI. Given that the legacy FG for unified TCI indication (FG23-1-1b, 23-10-1b) refers the legacy DCI formats, it may be better to introduce new FGs for unified TCI indication with DCI format 1\_3.  **Proposal 9: Introduce following FG for unified TCI with joint DL/UL TCI update by DCI format 1\_3 (based on 23-1-1b).**   * FG name   + Unified TCI with joint DL/UL TCI update by DCI format 1\_3 for intra- and inter-cell beam management with more than one MAC-CE activated joint TCI state per CC * Component   + 1: TCI state indication for update and activation     - b) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_3 with DL assignment)     - c) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_3 without DL assignment)   + 2: The minimum beam application time in Y symbols per SCS   + 3: The maximum number of MAC-CE activated joint TCI states per CC in a band * Prerequisite   + 23-1-1, At least one of {49-1, 49-1b} * Type   + Per BC * Note   + Component 2 candidate values: {1, 2, 4, 7, 14, 28, 42, 56, 70, 84, 98, 112, 224, 336}, where {84, 98, 112, 224, 336} only can be indicated in FR2   + Component 3 candidate values: {2, 3, 4, 5, 6, 7, 8}   + Note: The maximum number of MAC-CE activated joint TCI states across all CC(s) in a band for more than one MAC-CE activated joint TCI state is signaled in 23-1-1, component 5   + Note: activated joint TCI state(s) include all PDCCH/PDSCH receptions and PUSCH/PUCCH * Mandatory or optional   + Optional with capability signaling   **Proposal 10: Introduce following FG for unified TCI with separate DL/UL TCI update by DCI format 1\_3 (based on 23-10-1b).**   * FG name   + Unified TCI with separate DL/UL TCI update by DCI format 1\_3 for intra-cell beam management with more than one MAC-CE activated separate TCI state per CC * Component   + TCI state indication for update and activation     - b) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_3 with DL assignment)     - c) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_3 without DL assignment)   + The minimum beam application time in Y symbols per SCS   + The maximum number of MAC-CE activated DL TCI states per CC in a band   + The maximum number of MAC-CE activated UL TCI states per CC in a band * Prerequisite   + 23-10-1, At least one of {49-1, 49-1b} * Type   + Per BC * Note   + If a UE supports FG 23-10-1m, the signalled component values also apply to inter-cell beam management * Mandatory or optional   + Optional with capability signaling  BWP switching According to the discussion at the RAN1#116bis meeting, it was pointed that the legacy FGs for BWP switching are not DCI format specific. However, the UE behaviour for BWP switching with by DCI format 0\_3/1\_3 is extended from that for legacy DCI formats, and hence we think it is better to introduce new FG. In our view, it is not necessary to introduce separate FGs for DCI format 0\_3 and 1\_3.  It should be noted that whether to introduce new FG related to dormant BWP switching on multiple CCs RRM requirements for DCI format 0\_3/1\_3 should be discussed in RAN4.  **Proposal 11: Introduce following FG for BWP switching with same numerology by DCI format 0\_3/1\_3.**   * FG name   + BWP switching with same numerology by DCI format 0\_3/1\_3 * Component   + Support of BWP switching with same numerology by DCI format 0\_3/1\_3 * Prerequisite   + At least one of {49-1, 49-1b, 49-2, 49-2b} * Type   + Per BC * Note   + None * Mandatory or optional   + Optional with capability signaling   **Proposal 12: Introduce following FG for BWP switching with different numerology by DCI format 0\_3/1\_3.**   * FG name   + BWP switching with different numerology by DCI format 0\_3/1\_3 * Component   + Support of BWP switching with different numerology by DCI format 0\_3/1\_3 * Prerequisite   + At least one of {49-1, 49-1b, 49-2, 49-2b} * Type   + Per BC * Note   + None * Mandatory or optional   + Optional with capability signaling  480/960 kHz SCS for multi-cell scheduling In our view, especially for large SCS such as 480/960 kHz SCS, multi-slot scheduling is essential feature while it is not supported with DCI format 0\_3/1\_3. In that sense, we don’t see the strong need to support 480/960 kHz SCS with DCI format 0\_3/1\_3.  Given that candidate value of supporting carrier type is up to 120 kHz SCS in basic feature, 480/960 kHz SCS are not supported for multi-cell scheduling with DCI format 0\_3/1\_3 (i.e., only 120 kHz SCS is supported for FR2-2) based on the current basic FGs of multi-cell scheduling.  **Proposal 13: Conclude that 480/960 kHz SCS is not supported for multi-cell scheduling with DCI format 0\_3/1\_3.** |

## **Discussion**

### FG49-6/6a/7/8

#### **Proposal 2-1:**

* **For FG49-6, “For component 6, same values as for FG11-4 are reported (if the UE also report FG11-4)” is added in Note column.**
* **For FG49-6a, “For component 6, same values as for FG11-4a are reported (if the UE also report FG11-4a)” is added in Note column.**
* **For FG49-7, “For component 4 and 5, same values as for FG12-1 are reported (if the UE also report FG12-1)” is added in Note column.**
* **For FG49-8, “For component 3 and 4, same values as for FG25-7 are reported (if the UE also report FG25-7)” is added in Note column.**

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | **Summary of companies’ view:**   * Nokia: To guarantee coherent UE reporting on some UE features for DCI formats 0\_3/1\_3 and the (single cell) legacy DCI formats, add the related notes to FG 49-6, 49-6a, 49-7 and 49-8 (similar as the existing note to 49-5b). |
| Qualcomm | We are OK with the proposal. |
| OPPO | Ok |
| Nokia | OK / support |

### FG49-8

#### **Proposal 2-2:**

* **Remove “25-7” from prerequisite of FG49-8**

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | **Summary of companies’ view:**   * OPPO: FG49-8 is cloned from legacy FG25-7 by copying all FG components, Types and Note field of FG25-7 with necessary modifications as highlighted in the agreement. Then it is unnecessary and even misleading to take, at meanwhile, FG25-7 as a prerequisite of new FG49-8. |
| Qualcomm | Agree with the proposal. |
| OPPO | Support |
| Vivo | agree |

### Unified-TCI indication by DCI format 1\_3

#### **(H) Proposal 2-3-1:**

**Introduce following FG for unified TCI with joint DL/UL TCI update by DCI format 1\_3 (based on 23-1-1b).**

* FG name
  + Unified TCI with joint DL/UL TCI update by DCI format 1\_3 for intra- and inter-cell beam management with more than one MAC-CE activated joint TCI state per CC
* Component
  + 1: TCI state indication for update and activation
    - b) MAC-CE+DCI-based TCI state indication (use of DCI format 1\_3 with DL assignment)
    - c) MAC-CE+DCI-based TCI state indication (use of DCI format 1\_3 without DL assignment)
  + 2: The minimum beam application time in Y symbols per SCS
  + 3: The maximum number of MAC-CE activated joint TCI states per CC in a band
* Prerequisite
  + 23-1-1, At least one of {49-1, 49-1b}
* Type
  + Per BC
* Note
  + Component 2 candidate values: {1, 2, 4, 7, 14, 28, 42, 56, 70, 84, 98, 112, 224, 336}, where {84, 98, 112, 224, 336} only can be indicated in FR2
  + Component 3 candidate values: {2, 3, 4, 5, 6, 7, 8}
  + Note: The maximum number of MAC-CE activated joint TCI states across all CC(s) in a band for more than one MAC-CE activated joint TCI state is signaled in 23-1-1, component 5
  + Note: activated joint TCI state(s) include all PDCCH/PDSCH receptions and PUSCH/PUCCH
* Mandatory or optional
  + Optional with capability signaling

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | **Summary of companies’ view:**   * Support new FG based on 23-1-1b: Huawei/HiSilicon, Samsung, NTT DOCOMO   + Component     - Support “use of DCI format 1\_3 without DL assignment”: NTT DOCOMO     - FFS “use of DCI format 1\_3 without DL assignment”: Samsung   + Prerequisite     - 23-1-1: Huawei/HiSilicon     - 23-1-1, At least one of {49-1, 49-1b}: Samsung, NTT DOCOMO   + Type     - Per band: Huawei/HiSilicon, Samsung     - Per BC: NTT DOCOMO |
| Qualcomm | We support to introduce the new FG.   * + Component     - “use of DCI format 1\_3 without DL assignment” should be deleted for now (even no FFS preferred). Discussion in maintenance on this is necessary before capturing in the FG.   + Prerequisite     - Should be “23-1-1, At least one of {49-1, 49-1b}”   + Type     - Per band |
| OPPO | Same view as from Qualcomm. |
| vivo | * + Component     - c) MAC-CE+DCI-based TCI state indication (use of DCI format 1\_3 without DL assignment)   we suggest postpone the discussion as there is ongoing discussion in maintenance   * + Prerequisite   + Type     - We think this should be per-BC, as this is for joint TCI indication for multiple cells. |
| Nokia | OK to introduce   * + Component     - Agree with QC – maybe we leave b) and c) both for FFS for now, and come back with the final formulation after clarification in maintenance session   + Prerequisite     - Should be “23-1-1, At least one of {49-1, 49-1b}”   + Type     - Per band   + Note     - We think again, that the similar not to have consistent reporting with 23-1-1b – so having the following additional notes       * For component 2 and 3, same values as for FG23-1-1b are reported (if the UE also report FG23-1-1b) |
|  |  |

#### **(H) Proposal 2-3-2:**

**Introduce following FG for unified TCI with separate DL/UL TCI update by DCI format 1\_3 (based on 23-10-1b).**

* FG name
  + Unified TCI with separate DL/UL TCI update by DCI format 1\_3 for intra-cell beam management with more than one MAC-CE activated separate TCI state per CC
* Component
  + TCI state indication for update and activation
    - b) MAC-CE+DCI-based TCI state indication (use of DCI format 1\_3 with DL assignment)
    - c) MAC-CE+DCI-based TCI state indication (use of DCI format 1\_3 without DL assignment)
  + The minimum beam application time in Y symbols per SCS
  + The maximum number of MAC-CE activated DL TCI states per CC in a band
  + The maximum number of MAC-CE activated UL TCI states per CC in a band
* Prerequisite
  + 23-10-1, At least one of {49-1, 49-1b}
* Type
  + Per BC
* Note
  + If a UE supports FG 23-10-1m, the signalled component values also apply to inter-cell beam management
* Mandatory or optional
  + Optional with capability signaling

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | **Summary of companies’ view:**   * Support new FG based on 23-10-1b: Huawei/HiSilicon, Samsung, NTT DOCOMO   + Component     - Support “use of DCI format 1\_3 without DL assignment”: NTT DOCOMO     - FFS “use of DCI format 1\_3 without DL assignment”: Samsung   + Prerequisite     - 23-10-1: Huawei/HiSilicon     - 23-10-1, At least one of {49-1, 49-1b}: Samsung, NTT DOCOMO   + Type     - Per band: Huawei/HiSilicon, Samsung     - Per BC: NTT DOCOMO |
| Qualcomm | * + Component     - “use of DCI format 1\_3 without DL assignment” should be deleted for now (even no FFS preferred). Discussion in maintenance on this is necessary before capturing in the FG.   + Prerequisite     - Should be “23-10-1, At least one of {49-1, 49-1b}”   + Type     - Per band |
| OPPO | Same preference as from Qualcomm. |
| vivo | Same comments as Proposal 2-3-1 |
| Nokia | Agree with QC – maybe just put both b) and c) under FFS and come up with a final formulation after having clarified in the maintenance session |

### PHY priority handling for one-shot HARQ-ACK feedback triggered by DCI format 1\_3

#### **(H) Proposal 2-4:**

**Introduce new FG for PHY priority handling for one-shot HARQ-ACK feedback triggered by DCI format 1\_3 (based on 25-5)**

* FG name:
  + PHY priority indication for one-shot HARQ-ACK feedback triggered by DCI format 1\_3
* Component:
  + Support transmission of type 3 HARQ-ACK codebook using the first or second PUCCH configuration based on PHY priority indication in the triggering DCI format 1\_3
* Prerequisite:
  + 49-5a and 49-6
* Type:
  + Per UE without differentiation
* Note:
  + None
* Mandatory or Optional:
  + Optional with capability signaling

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | **Summary of companies’ view:**   * Support new FG based on 25-5: Huawei/HiSilicon, ZTE (FG name should be “PHY priority indication for one-shot HARQ-ACK feedback triggered by DCI format 1\_3” and the reporting type should be “per UE without differentiation”) * Not support new FG based on 25-5: NTT DOCOMO (the existing FGs for PHY priority handling for one-shot HARQ-ACK feedback is reused for DCI format 1\_3) |
| Qualcomm | We are open to have the new FG. |
| OPPO | FG 25-5 has type as “per band”, so we prefer to have the same here.  We are supportive to all other bullets and main proposal. |
| vivo | We support most bullets of the proposal, but regarding the type, we share similar view as oppo. |
| Nokia | We are open to have this additional FG.   But agree with moderator, that per UE should be sufficient here. |

### BWP switching by DCI format 1\_3/0\_3

#### **(H) Proposal 2-5-1:**

**Introduce following FG for BWP switching with same numerology by DCI format 0\_3/1\_3.**

* FG name
  + BWP switching with same numerology by DCI format 0\_3/1\_3
* Component
  + Support of BWP switching with same numerology by DCI format 0\_3/1\_3
* Prerequisite
  + At least one of {49-1, 49-1b, 49-2, 49-2b}
* Type
  + Per BC
* Note
  + None
* Mandatory or optional
  + Optional with capability signaling

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | **Summary of companies’ view:**   * Support new FG for BWP switching by DCI format 1\_3/0\_3: NTT DOCOMO   + the UE behaviour for BWP switching with by DCI format 0\_3/1\_3 is extended from that for legacy DCI formats, and hence we think it is better to introduce new FG * Not support new FG for BWP switching by DCI format 1\_3/0\_3: ZTE   + In the legacy, if the UE supports more than one BWPs, the UE should support BWP switching including DCI-based BWP switching and timer-based BWP switching. This is not relevant to the DCI formats. Therefore, there is no need to introduce feature group on DCI format 1\_3/0\_3 based BWP switching. |
| Qualcomm | Agree with DOCOMO that we should consider new FG for BWP switching by DCI format 1\_3/0\_3. Updates in Rel-18 maintenance session may require additional considerations, e.g., further new FGs may be necessary depending on the outcome of maintenance discussion. |
| OPPO | We slightly prefer to have a new FG. |
| vivo | We support new FG |
| Nokia | We don’t see a need for this new FG, and agree with the comments by ZTE above. |

#### **(H) Proposal 2-5-2:**

**Introduce following FG for BWP switching with different numerology by DCI format 0\_3/1\_3.**

* FG name
  + BWP switching with different numerology by DCI format 0\_3/1\_3
* Component
  + Support of BWP switching with different numerology by DCI format 0\_3/1\_3
* Prerequisite
  + At least one of {49-1, 49-1b, 49-2, 49-2b}
* Type
  + Per BC
* Note
  + None
* Mandatory or optional
  + Optional with capability signaling

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | **Summary of companies’ view:**   * Support new FG for BWP switching by DCI format 1\_3/0\_3: NTT DOCOMO   + the UE behaviour for BWP switching with by DCI format 0\_3/1\_3 is extended from that for legacy DCI formats, and hence we think it is better to introduce new FG * Not support new FG for BWP switching by DCI format 1\_3/0\_3: ZTE   + In the legacy, if the UE supports more than one BWPs, the UE should support BWP switching including DCI-based BWP switching and timer-based BWP switching. This is not relevant to the DCI formats. Therefore, there is no need to introduce feature group on DCI format 1\_3/0\_3 based BWP switching. |
| Qualcomm | Agree with DOCOMO that we should consider new FG for BWP switching by DCI format 1\_3/0\_3. Updates in Rel-18 maintenance session may require additional considerations, e.g., further new FGs may be necessary depending on the outcome of maintenance discussion. |
| OPPO | We slightly prefer to have a new FG. |
| vivo | We support new FG |
| Nokia | Same as for 2-5-1, i.e. we don’t see a need for this new FG, and agree with the comments by ZTE above. |

### 480/960 kHz SCS for multi-cell scheduling

#### **Proposal 2-6:**

**Conclude that 480/960 kHz SCS is not supported for multi-cell scheduling with DCI format 0\_3/1\_3**

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | **Summary of companies’ view:**   * NTT DOCOMO: Given that candidate value of supporting carrier type is up to 120 kHz SCS in basic feature, 480/960 kHz SCS are not supported for multi-cell scheduling with DCI format 0\_3/1\_3 (i.e., only 120 kHz SCS is supported for FR2-2) based on the current basic FGs of multi-cell scheduling |
| Qualcomm | OK with the DOCOMO’s conclusion. |
| OPPO | Support the proposal. |
| vivo | OK |
| Nokia | Ok with the proposal / conclusion |

# **FGs for multi-carrier UL Tx switching scheme**

No inputs are provided in contributions for the RAN1#117 meeting.

# **Conclusions**

TBD

# **References**

[1] R1-2403703 Updated RAN1 UE features list for Rel-18 NR after RAN1#116bis Moderators (AT&T, NTT DOCOMO, INC.)

[2] R1-2403918 UE features for other Rel-18 work items (Topics A) Huawei, HiSilicon

[3] R1-2404006 Discussion on UE feature topics A ZTE

[4] R1-2404101 UE features for other Rel-18 work items (Topics A) Samsung

[5] R1-2404484 UE Features for Other Topics A (SLenh, MCenh, MBS, Sub-5MHz) Nokia

[6] R1-2404857 Discussion on UE features for multi-carrier enhancement OPPO

[7] R1-2405028 Discussion on UE features for other Rel-18 work items (Topics A) NTT DOCOMO, INC.

# **Appendix: UE features list for Rel-18 NR\_MC\_enh**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (Sidelink WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 49. NR\_MC\_enh | 49-1 | Multi-cell PDSCH scheduling by DCI format 1\_3 on a scheduling cell with same SCS between scheduling cell and cells in the set | 1) UE supports monitoring DCI format 1\_3 for DL scheduling with same SCS between scheduling cell and cells in the set  2) Scheduling cell is PCell if set of cells includes PCell, and scheduling cell is PCell or an SCell if set of cells includes only SCells.  3) Scheduling cell and co-scheduled cells have same SCS/carrier type: value set: {FR1 licensed FDD, FR1 licensed TDD, FR1 unlicensed TDD, FR2-1, FR2-2}, UE reports one or multiple of values from the value set  4) Max number of co-scheduled cells per set of cells supported by UE is reported with candidate value set of {2, 3, 4}  5) Max number of sets of cells supported by UE across PUCCH groups: Candidate value set of {1, 2, 3, 4, 5, 6, 7, 8}  6) Max number of sets of cells supported by UE for a same scheduling cell: Candidate value set of {1, 2, 3, 4}  7) Supported HARQ feedback types, candidate values: {type 1, type2, type 1 and type 2}, Note: the UE shall report the same value for all supported BC for FG 49-1  8) Supported co-scheduled cell indication schemes: Candidate value set of {FDRA field based, co-scheduled cell indicator field based, both}  9) Support Type-2 for ‘Antenna port(s)’ field  10) The number of unicast DL DCIs to process per slot of scheduling cell for a set of cells configured for multi-cell PDSCH scheduling by DCI format 1\_3   * One DCI format 1\_3 for the set of cells and, * One unicast DL DCI formats 1\_0/1\_1/1\_2 (if supported) for each of the cells that are not scheduled by DCI 1\_3   11) Monitoring SS set(s) for DCI format 1\_3 for a set of cells for the following cases   * 1) Search space set configuration for DCI format 1\_3 for the set of cells is provided only on the scheduling cell, or; * 2) Search space set configurations for DCI format 1\_3 for the set of cells with the same searchSpaceId are provided on both the scheduling cell and a serving cell in the set of cells with the scheduling cell being NOT in the set of cells * UE supporting FG 49-1 can additionally report whether the UE support following case   + 3) Search space set configurations for DCI format 1\_3 for the set of cells with the same searchSpaceId are provided on both the scheduling cell and a serving cell in the set of cells with the scheduling cell being in the set of cells   12) When multiple component 3 values are reported and if scheduling cell is not included in the set of cells, support multi-cell PDSCH scheduling by DCI format 1\_3 from one carrier type, indicated in component 3, to another carrier type, indicated in component 3, for the following scheduling cases:   * FR1 licensed TDD to FR1 unlicensed TDD * FR2-1 to FR2-2 * UE can additionally report the support of {FR1 licensed FDD from/to FR1 licensed TDD} |  | Yes |  | UE does not support multi-cell PDSCH scheduling by DCI format 1\_3 on a scheduling cell with same SCS between scheduling cell and cells in the set | Per BC | N/A | N/A | N/A | Note: Support of CCS with DL DCI formats 1\_1/1\_2 is according to FG 6-10 | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-1b | Multi-cell PDSCH scheduling by DCI format 1\_3 on a scheduling cell not included in a set of cells with different SCS/carrier type between scheduling cell and cells in the set | 1) UE supports monitoring DCI format 1\_3 for DL scheduling where scheduling cell is not included in a set of cells in same PUCCH group.  2) Scheduling cell is PCell or SCell, and a set of cells includes only SCells.  3a) Scheduling cell and co-scheduled cells have different SCS. The set of co-scheduled cells share the same SCS and carrier type  Candidate value set for component 3a:   * {Scheduling cell of lower SCS and scheduled cells of higher SCS, Scheduling cell of higher SCS and scheduled cells of lower SCS, both}   3b) Scheduling cell and co-scheduled cells have same or different carrier type (FR1 licensed FDD or FR1 licensed TDD or FR1 unlicensed TDD or FR2-1 or FR2-2).  Candidate value set for component 3b:   * Indication of support/not support for each of applicable combinations of scheduling cell from {FR1 licensed FDD, FR1 licensed TDD, FR1 unlicensed TDD, FR2-1, FR2-2} and scheduled cells from {FR1 licensed FDD, FR1 licensed TDD, FR1 unlicensed TDD, FR2-1, FR2-2} from the band combinations   4) Max number of co-scheduled cells per set of cells supported by UE is reported with candidate value set of {2, 3, 4}  5) Max number of sets of cells supported by UE across PUCCH groups: Candidate value set of {1, 2, 3, 4, 5, 6, 7, 8}  6) Max number of sets of cells supported by UE for a same scheduling cell: Candidate value set of {1, 2, 3, 4}  7) Supported HARQ feedback types, candidate values: {type 1, type2, type 1 and type 2}, Note: the UE shall report the same value for all supported BC for FG 49-1b  8) Supported co-scheduled cell indication schemes: Candidate value set of {FDRA field based, co-scheduled cell indicator field based, both}  9) Support Type-2 for ‘Antenna port(s)’ field  10) The number of unicast DL DCIs to process per N consecutive slots of scheduling cell for a set of cells configured for multi-cell PDSCH scheduling by DCI format 1\_3   * One DCI format 1\_3 for the set of cells and, * One unicast DL DCI formats 1\_0/1\_1/1\_2 (if supported) for each of the cells that are not scheduled by DCI 1\_3 * For low-to-high SCS, N = 1. * For high-to-low SCS, N is based on pair of (scheduling CC SCS, scheduled CC SCS): N=2 for (30,15), (60,30), (120,60) and N=4 for (60,15), (120,30), N = 8 for (120,15)   11) Monitoring SS set(s) for DCI format 1\_3 for a set of cells for the following cases   * 2) Search space set configurations for DCI format 1\_3 for the set of cells with the same searchSpaceId are provided on both the scheduling cell and a serving cell in the set of cells |  | Yes |  | UE does not support multi-cell PDSCH scheduling by DCI format 1\_3 on a scheduling cell which is not included in a set of cells with different SCS/carrier type scheduling cell and cells in the set | Per BC | N/A | N/A | N/A | Note: Support of CCS with DL DCI formats 1\_1/1\_2 is according to FG 18-5 | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-2 | Multi-cell PUSCH scheduling by DCI format 0\_3 on a scheduling cell with same SCS between scheduling cell and cells in the set | 1) UE supports monitoring DCI format 0\_3 for UL scheduling with same SCS between scheduling cell and cells in the set  2) Scheduling cell is PCell if set of cells includes PCell, and scheduling cell is PCell or an SCell if set of cells includes only SCells.  3) Scheduling cell and co-scheduled cells have same SCS/carrier type:value set: {FR1 licensed FDD, FR1 licensed TDD, FR1 unlicensed TDD, FR2-1, FR2-2}, UE reports one or multiple of values from the value set  4) Max number of co-scheduled cells per set of cells supported by UE is reported with candidate value set of {2, 3, 4}  5) Max number of sets of cells supported by UE across PUCCH groups: Candidate value set of {1, 2, 3, 4, 5, 6, 7, 8}  6) Max number of sets of cells supported by UE for a same scheduling cell: Candidate value set of {1, 2, 3, 4}  7) Supported co-scheduled cell indication schemes: Candidate value set of {FDRA field based, co-scheduled cell indicator field based, both}  8) Support Type-2 for ‘Antenna port(s)’, ‘Precoding information and number of layers’ and ‘SRS resource indicator’ fields  9) The number of unicast UL DCIs to process per slot of scheduling cell for a set of cells configured for multi-cell PUSCH scheduling by DCI format 0\_3   * For FDD scheduling cell   + Up to one DCI format 0\_3 for the set of cells and,   + Up to one unicast UL DCI formats 0\_0/0\_1/0\_2 (if supported) for each of the cells   + For a cell in a set of cells, no more than one DCI scheduling PUSCH for the cell * For TDD scheduling cell   + Up to two DCI format 0\_3 for the set of cells and,   + Up to two unicast UL DCI formats 0\_0/0\_1/0\_2 (if supported) for each of the cells   + For a cell in a set of cells, no more than two DCI scheduling PUSCH for the cell   10) Monitoring SS set(s) for DCI format 0\_3 for a set of cells for the following cases   * 1) Search space set configuration for DCI format 0\_3 for the set of cells is provided only on the scheduling cell, or; * 2) Search space set configurations for DCI format 0\_3 for the set of cells with the same searchSpaceId are provided on both the scheduling cell and a serving cell in the set of cells with the scheduling cell being NOT in the set of cells * UE supporting FG 49-2 can additionally report whether the UE support following case   + 3) Search space set configurations for DCI format 0\_3 for the set of cells with the same searchSpaceId are provided on both the scheduling cell and a serving cell in the set of cells with the scheduling cell being in the set of cells   11) - When multiple component 3 values are reported and if scheduling cell is not included in the set of cells, support multi-cell PUSCH scheduling by DCI format 0\_3 from one carrier type, indicated in component 3, to another carrier type, indicated in component 3, for the following scheduling cases:   * FR1 licensed TDD to FR1 unlicensed TDD * FR2-1 to FR2-2 * UE can additionally report the support of {FR1 licensed FDD from/to FR1 licensed TDD} |  | Yes |  | UE does not support multi-cell PUSCH scheduling by DCI format 0\_3 on a scheduling cell with same SCS between scheduling cell and cells in the set | Per BC | N/A | N/A | N/A | Note: Support of CCS with UL DCI formats 0\_1/0\_2 is according to FG 6-10 | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-2b | Multi-cell PUSCH scheduling by DCI format 0\_3 on a scheduling cell not included in a set of cells with different SCS/carrier type between scheduling cell and cells in the set | 1) UE supports monitoring DCI format 0\_3 for UL scheduling where scheduling cell is not included in a set of cells in same PUCCH group.  2) Scheduling cell is PCell or SCell, and a set of cells includes only SCells.  3a) Scheduling cell and co-scheduled cells have different SCS. The set of co-scheduled cells share the same SCS and carrier type  Candidate value set for component 3a:   * {Scheduling cell of lower SCS and scheduled cells of higher SCS, Scheduling cell of higher SCS and scheduled cells of lower SCS, both}   3b) Scheduling cell and co-scheduled cells have same or different carrier type (FR1 licensed FDD or FR1 licensed TDD or FR1 unlicensed TDD or FR2-1 or FR2-2).  Candidate value set for component 3b:   * Indication of support/not support for each of applicable combinations of scheduling cell from {FR1 licensed FDD, FR1 licensed TDD, FR1 unlicensed TDD, FR2-1, FR2-2} and scheduled cells from {FR1 licensed FDD, FR1 licensed TDD, FR1 unlicensed TDD, FR2-1, FR2-2} from the band combinations   4) Max number of co-scheduled cells per set of cells supported by UE is reported with candidate value set of {2, 3, 4}  5) Max number of sets of cells supported by UE across PUCCH groups: Candidate value set of {1, 2, 3, 4, 5, 6, 7, 8}  6) Max number of sets of cells supported by UE for a same scheduling cell: Candidate value set of {1, 2, 3, 4}  7) Supported co-scheduled cell indication schemes: Candidate value set of {FDRA field based, co-scheduled cell indicator field based, both}  8) Support Type-2 for ‘Antenna port(s)’, ‘Precoding information and number of layers’ and ‘SRS resource indicator’ fields  9) The number of unicast UL DCIs to process per N consecutive slots of scheduling cell for a set of cells configured for multi-cell PUSCH scheduling by DCI format 0\_3   * For FDD scheduling cell   + Up to one DCI format 0\_3 for the set of cells and,   + Up to one unicast UL DCI formats 0\_0/0\_1/0\_2 (if supported) for each of the cells   + For a cell in a set of cells, no more than one DCI scheduling PUSCH for the cell * For TDD scheduling cell   + Up to two DCI format 0\_3 for the set of cells and,   + Up to two unicast UL DCI formats 0\_0/0\_1/0\_2 (if supported) for each of the cells   + For a cell in a set of cells, no more than two DCI scheduling PUSCH for the cell * For low-to-high SCS, N = 1. * For high-to-low SCS, N is based on pair of (scheduling CC SCS, scheduled CC SCS): N=2 for (30,15), (60,30), (120,60) and N=4 for (60,15), (120,30), N = 8 for (120,15)   10) Monitoring SS set(s) for DCI format 0\_3 for a set of cells for the following cases   * 2) Search space set configurations for DCI format 0\_3 for the set of cells with the same searchSpaceId are provided on both the scheduling cell and a serving cell in the set of cells |  | Yes |  | UE does not support multi-cell PUSCH scheduling by DCI format 0\_3 on a scheduling cell which is not included in a set of cells with different SCS/carrier type scheduling cell and cells in the set | Per BC | N/A | N/A | N/A | Note: Support of CCS with UL DCI formats 0\_1/0\_2 is according to FG 18-5b | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-3x | Advanced UE capability for larger number of unicast DL DCI | Processing up to X unicast DCI scheduling PDSCH per scheduled cell in a set of cells configured for multi-cell PDSCH scheduling by DCI format 1\_3:   * Up to X DCI formats 1\_3 for the set of cells, and * Up to X unicast DL DCI formats 1\_0/1\_1/1\_2 (if supported) for each of the cells in the set of cells * For each cell in the set of cells, no more than X DCIs scheduling PDSCH for the cell * X is based on pair of (scheduling CC SCS, scheduled CC SCS):   + Candidate value(s) of X     - X={2,4} for (15,120), (15,60), (30,120) and X={2} for (15,30), (30,60), (60,120 kHz)   + X applies per slot of scheduling CC | 49-1b | Yes |  |  | Per BC | N/A | N/A | N/A |  | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-3y | Advanced UE capability for larger number of unicast UL DCI | Processing up to X unicast DCI scheduling PUSCH per scheduled cell in a set of cells configured for multi-cell PUSCH scheduling by DCI format 0\_3   * Up to X DCI formats 0\_3 for the set of cells, and * Up to X unicast UL DCI formats 0\_0/0\_1/0\_2 (if supported) for each of the cells in the set of cells * For a cell in the set of cells, no more than X DCIs scheduling PUSCH for the cell * X is based on pair of (scheduling CC SCS, scheduled CC SCS):   + Candidate value(s) of X     - X={2,4} for (15,120), (15,60), (30,120) and X={2} for (15,30), (30,60), (60,120 kHz)   + X applies per slot of scheduling CC | 49-2b | Yes |  |  | Per BC | N/A | N/A | N/A |  | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-4a | Nominal RBG size of Configuration 3 for FDRA type 0 for DCI format 1\_3 | 1) Support of nominal RBG size of Configuration 3 for FDRA type 0 for DCI format 1\_3 | At least one of {49-1, 49-1b} | Yes |  |  | Per UE | No | No | No |  | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-4b | Nominal RBG size of Configuration 3 for FDRA type 0 for DCI format 0\_3 | 1) Support of nominal RBG size of Configuration 3 for FDRA type 0 for DCI format 0\_3 | At least one of {49-2, 49-2b} | Yes |  |  | Per UE | No | No | No |  | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-4c | Configurable Type-1A fields for DCI format 0\_3/1\_3 | 1) Support Type-1A for ‘Antenna port(s)’ field for DCI format 1\_3  2) Support Type-1A for ‘Antenna port(s)’, ‘Precoding information and number of layers’ and ‘SRS resource indicator’ fields for DCI format 0\_3 | At least one of {49-1, 49-1b, 49-2, 49-2b} | Yes |  |  | Per UE | No | No | No |  | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-4d | FDRA Type 1 granularity of 2, 4, 8, or 16 consecutive RBs based RIV for DCI format 1\_3/0\_3 | 1) Support of FDRA Type 1 granularity of 2, 4, 8, or 16 consecutive RBs based RIV for DCI format 0\_3  2) Support of FDRA Type 1 granularity of 2, 4, 8, or 16 consecutive RBs based RIV for DCI format 1\_3 | At least one of {49-1, 49-1b, 49-2, 49-2b} | Yes |  |  | Per UE | No | No | No |  | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-5a | Trigger Type 3 HARQ CB based feedback using DCI format 1\_3 | 1. Support feedback of type 3 HARQ-ACK codebook, triggered by a DCI 1\_3 scheduling at least a PDSCH  2. Support feedback of type 3 HARQ-ACK codebook, triggered by a DCI 1\_3 without scheduling a PDSCH using a reserved FDRA value | At least one of {49-1, 49-1b} | Yes |  | UE does not support HARQ feedback based on Type 3 HARQ codebook triggered by DCI format 1\_3 | Per BC | N/A | N/A | N/A | Upon triggering, UE reports A/N for all HARQ processes and all CCs in a PUCCH group. | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-5b | Trigger enhanced Type 3 HARQ CB based feedback using DCI format 1\_3 | 1. Support feedback of enhanced type 3 HARQ-ACK codebook, triggered by a DCI 1\_3  2. Support configuration of up to 8 enhanced type 3 HARQ-ACK codebooks.  3. Support feedback of a dynamically selected enhanced type 3 HARQ-ACK codebook based on triggering information in DCI 1\_3  4. Support transmission of enhanced type 3 HARQ-ACK codebook using the first or second PUCCH configuration based on PHY priority indication in the triggering DCI (for a UE supporting two HARQ-ACK codebooks / PUCCH config in 49-6)  5. Supported maximum number of actual PUCCH transmissions for type 3 or enhanced type 3 HARQ-ACK codebook feedback within a slot | At least one of {49-1, 49-1b} | Yes |  | UE does not support HARQ feedback based on enhanced Type 3 HARQ codebook triggered by DCI format 1\_3 | Per BC | N/A | N/A | N/A | For component 2, the UE indicates its capability in the number of enhanced type 3 HARQ-ACK codebooks: {1, 2, 4, 8}  For component 3, the dynamic indication is only supported if the UE for component 2 supports more than one enhanced type 3 HARQ-ACK codebook to be configured  Candidate values for component 5 is: {1, 2, 3, 4, 5, 6, 7}.  For component 2 and 5, same values as for FG25-6 are reported (if the UE also report FG25-6) | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-6 | Two HARQ-ACK codebooks with up to one sub-slot based HARQ-ACK codebook simultaneously constructed for supporting HARQ-ACK codebooks with different priorities by DCI format 1\_3 | 1. Supports two HARQ-ACK codebooks with different priorities to be simultaneously constructed with the restriction up to one sub-slot based HARQ-ACK codebook.  2. Supports separate PUCCH configuration for different HARQ-ACK codebooks.  3. Supports 2-level priority of HARQ-ACK for dynamically scheduled PDSCH and SPS PDSCH.  4. Supports a DCI format 1\_3 scheduling PDSCH with different HARQ-ACK priorities when only DCI format 0\_3/1\_3 is configured per BWP.  5. Supports separate configuration of parameters PDSCH-HARQ-ACK-Codebook, UCI-OnPUSCH and 'codeBlockGroupTransmission" for different HARQ-ACK codebooks.  6. Supported maximum number of actual PUCCH transmissions for HARQ-ACK within a slot   * Candidate values for the component 6 of this FG is: For NCP, {4, 5, 6, 7} for 2-symbol\*7 sub-slot configuration; For ECP, the candidate value is {4,5,6} for 2-symbol\*6 sub-slot configuration   7. Support intra-UE multiplexing/prioritization of UL overlapping channels/signals with two priority levels for HARQ-ACK | At least one of {49-1, 49-1b} | Yes |  |  | Per FS | N/A | N/A | N/A | If a UE reports both 11-3 and this FG, it can support two slot-based HARQ-ACK codebooks, and one slot-based and one-sub-slot-based HARQ-ACK codebooks. If a UE reports this FG but not 11-3, it can only support two slot-based HARQ-ACK codebooks.  The number of PUCCHs for CSI reporting per slot is not impacted compared with Rel-15 by introducing the new HARQ-ACK CBs  Component 6 is applied to the sub-slot HARQ-ACK codebook. It is assumed that only 1 actual PUCCH transmission for HARQ-ACK within a slot for slot-based HARQ-ACK codebook.   * Component 6 is reported for 2-symbol\*7 sub-slot configuration. For 7-symbol\*2 sub-slot configuration, the value of component 6 is {2} for both NCP and ECP cases.   For component 6, maximum of 1 actual PUCCH transmission for HARQ-ACK within a slot for slot-based HARQ-ACK codebook. Thus value reported for component 6 has no meaning for "slot-based + slot based". | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-6a | Two HARQ-ACK codebooks with two sub-slot based HARQ-ACK codebook simultaneously constructed for supporting HARQ-ACK codebooks with different priorities by DCI format 1\_3 | 1. Supports two subslot based HARQ-ACK codebooks with different priorities to be simultaneously constructed.  2. Supports separate PUCCH configuration for different HARQ-ACK codebooks.  3. Supports 2-level priority of HARQ-ACK for dynamically scheduled PDSCH and SPS PDSCH.  4. Supports a DCI format 1\_3 scheduling PDSCH with different HARQ-ACK priorities when only DCI format 0\_3/1\_3 is configured in USS per BWP.  5. Supports separate configuration of parameters PDSCH-HARQ-ACK-Codebook, UCI-OnPUSCH and "codeBlockGroupTransmission" for different HARQ-ACK codebooks.  6. Supported maximum number of actual PUCCH transmissions for HARQ-ACK within a slot.   * Candidate values for the component 6 of this FG is: For NCP, {4, 5, 6, 7} for 2-symbol\*7 sub-slot configuration; For ECP, the candidate value is {4,5,6} for 2-symbol\*6 sub-slot configuration. | 11-3, 49-6 | Yes |  |  | Per FS | N/A | N/A | N/A | The number of PUCCHs for CSI reporting per slot is not impacted compared with Rel-15 by introducing the new HARQ-ACK CBs  Component 6 is applied to the two sub-slot HARQ-ACK codebooks, respectively.  Component 6 is reported for 2-symbol\*7 sub-slot configuration. For 7-symbol\*2 sub-slot configuration, the value of component 6 is {2} for both NCP and ECP cases. | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-6b | DL priority indication in DCI with mixed DCI formats including DCI format 1\_3 | Support of priority indicator field configured in DCI formats 1\_3 and (1\_1 or 1\_2) in a BWP when configured to monitor both DCI formats 1\_3 and (1\_1 or 1\_2) in the BWP | 49-6 |  |  |  | Per UE | No | No | N/A |  | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-7 | UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels in physical layer for DCI format 1\_3/0\_3 | Support intra-UE multiplexing/prioritization of overlapping PUCCH/PUCCH and PUCCH/PUSCH with two priority levels in physical layer (PHY) for DCI format 1\_3/0\_3  1) Configuration of PHY priority level for CG PUSCH and SR, and dynamic indication of priority level for dynamic PUSCH with a single DCI format 0\_3  2) Multiplexing/prioritization between UL channels/signals with the same PHY priority level  3) Prioritization between UL channels/signals with different PHY priority levels  4) Additional number of symbols (d1) needed beyond the PUSCH preparation time for cancelling a low priority UL transmission.  5) Additional number of symbols (d2) of the preparation time needed for the high priority UL transmission that cancels a low priority UL transmission | At least one of {49-1, 49-1b, 49-2, 49-2b} |  |  |  | Per FS | N/A | N/A | N/A | Candidate value set for component 4: {0, 1, 2}  Candidate value set for component 5: {0, 1, 2} | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-7a | UL priority indication in DCI with mixed DCI formats including DCI format 0\_3 | Support of priority indicator field configured in DCI formats 0\_3 and (0\_1 or 0\_2) in a BWP when configured to monitor both DCI formats 0\_3 and (0\_1 or 0\_2) in the BWP | 49-7 |  |  |  | Per UE | No | No | N/A |  | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-8 | Triggered HARQ-ACK codebook re-transmission for DCI format 1\_3 | 1. Support HARQ-ACK re-transmission from an earlier PUCCH slot based on the triggering information in DCI format 1\_3  2. Support the related PHY priority handling in terms of HARQ-ACK codebook selection and the applicable PUCCH configuration (for a UE supporting two HARQ-ACK codebooks / PUCCH config in 49-6)  3. Supported minimum value M for the HARQ re-tx offset  4. Supported maximum value N for the HARQ re-tx offset | 25-7 and at least one of {49-1, 49-1b} |  |  |  | Per band | N/A | N/A | N/A | Candidate values for component 3 is: M = {-7, -5, …, 1}  Candidate values for component 4 is: N= {4, 6, …, 24}  Note: The minimum requirement for Component 3 and Component 4 of this FG is valid for HARQ CBs consisted of HARQ Processes with a single HARQ bit per HARQ Process ID | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-9 | SCell dormancy indication within active time in DCI format 0\_3/1\_3 | Support for SCell dormancy indication sent within the active time on PCell with DCI format 0\_3/1\_3 | 6-5, at least one of {49-1, 49-1b, 49-2,49-2b} |  |  |  | Per BC | N/A | N/A | N/A | One dormant BWP and one non-dormant BWP is supported per carrier  More than one non-dormant BWP per carrier is supported only if UE feature 6-3/6-4 is also supported  One dormant BWP and one non-dormant BWP are UE specific BWPs even for UEs not supporting 6-2 or 6-3 | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-10 | Dynamic indication of applicable minimum scheduling restriction by DCI format 0\_3/1\_3 | 1) Dynamic indication of applicable minimum scheduling restriction by DCI format 0\_3 and 1\_3  2) minimumSchedulingOffset K0 configuration for PDSCH and aperiodic CSI-RS triggering offset  3) minimumSchedulingOffset K2 configuration for PUSCH  4) Support of extended value range for aperiodic CSI-RS triggering offset | At least one of {49-1, 49-1b, 49-2,49-2b} |  |  |  | Per UE | No | No | N/A |  | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-X | Supported switching option for each band pair in the band combination for UL Tx switching across more than 2 bands | Indicate supported switching option for each band pair in the band combination for UL Tx switching across more than 2 bands  Candidate value set is {switchedUL, dualUL, both} |  | Yes |  | UL Tx switching across more than 2 bands cannot be supported for the band pair in the band combination | Per band pair per band combination, details up to RAN2 | N/A | N/A | N/A | This FG is based on the following agreements. RAN1 will not discuss the detail of this FG and the detail is up to RAN2  Agreement  Ask RAN2 to consider following alternatives for UE capability reporting about the supported UL Tx switching options   * Alt.1: report {switchedUL, dualUL, both} for each band pair in the band combination   Agreement in RAN2#121  For UE capability of switching options, introduce a per-band-pair UE capability to report supported switching options for Rel-18 UL Tx switching. | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-Y | Minimum separation time for two uplink switching on more than 2 bands within any two consecutive reference slots | If two uplink switchings are triggered and UL transmissions involved in the two uplink switchings are on more than 2 bands within any two consecutive reference slots, then the time duration between the start of all transmission(s) after the first uplink switching and the start of all transmission(s) after the second uplink switching within the two reference slots is expected to be not less than a minimum separation time   * The minimum separation time is a maximum of X us and the switching gap required for the second uplink switching, and X us is reported with a candidate value set of {0us, 500us} * The reported value X is applied to both one TAG case and two-TAG case (if UE supports two-TAG case)   Note: If the UE reports 0us, the minimum separation time is not applied | 49-X | Yes |  |  | Per BC | N/A | N/A | N/A |  | Optional with capability signaling |