**3GPP TSG RAN WG1 #118 R1-2407198**

**Maastricht, NL, August 19th – 23rd, 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#117 [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
  + 49-11 PHY priority indication for one-shot HARQ-ACK feedback triggered by DCI format 1\_3
  + 49-12 Unified TCI with joint DL/UL TCI update by DCI format 1\_3 for intra-cell beam management with more than one MAC-CE activated joint TCI state per CC
  + 49-12a 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
* 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#118 meeting.

|  |  |  |
| --- | --- | --- |
| [3] | ZTE Corporation, Sanechips | In previous RAN1 meetings, whether to introduce a new UE feature on DCI format 0\_3/1\_3 based BWP switching was discussed. 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. When DCI format 0\_2/1\_2 was introduced, it is natural to support BWP switching indicated by DCI format 0\_2/1\_2. Therefore, there is no need to introduce feature group on DCI format 1\_3/0\_3 based BWP switching.  ***Proposal 1:*** *There is no need to introduce feature group for DCI format 1\_3/0\_3 based BWP switching.* |
| [4] | OPPO | In the existing UE feature framework, there are already following FGs being defined for BWP switching:   * FG6-2: Type A BWP adaptation with same numerology; * FG6-3: Type B BWP adaptation with same numerology; * FG6-4: BWP adaptation with different numerologies;   where each of above three FGs has a component stating “Active BWP switching by DCI and timer”, which seems to give a good reason for not defining new FGs for BWP switching using DCI 0\_3/1\_3. However, the above two proposed new FGs are still motivated by the following rational:   * The FG49-1 and FG49-2 indicating support of DCI 1\_3/0\_3 are defined per BC, while FG6-2/3/4 are defined per Band. So without new FGs as proposed in RAN1 #117, the logical combination of FG49-1/2 and FG6-2/3/4 gives a UE capability of DCI0\_3/1\_3-based BWP switching on a granularity of per Band and per Band-Combination, i.e., per feature-set, which goes more far away from the intention of simplifying the UE feature structure. This issue actually marks one of differences between DCI 0\_2/1\_2 (whose capability is per UE) and DCI 0\_3/1\_3 (whose capability is per BC) when it comes to capability interpretation in combination of {FG11-1 vs. FG49-1/2} and FG6-2/3/4. In other words, the way of capability signaling design of BWP switching based on legacy DCI such as DCI 0\_2/1\_2 may not fit well for the one based on DCI 0\_3/1\_3. * Without the new FGs as proposed in RAN1 #117, the following UE implementation combination (where UE observes different capabilities for DCI based BWP switching between legacy DCI and DCI 0\_3/1\_3), which may be preferred by UE vendors, would not be allowed:   + UE supports both BWP switching with ***same*** numerology and BWP switching with ***different*** numerologies (within a band) for DCI formats up to Rel-17; and meanwhile   + UE supports BWP switching with ***same*** numerology based on DCI 0\_3/1\_3, but has no capability for BWP switching with ***different*** numerologies based on DCI 0\_3/1\_3 (even though the UE may support FG49-1b for the BC’s).   Based on above analysis, we think it is necessary to define new FGs as proposed in RAN1 #117.  ***Proposal 1: Introduce new FGs as in Proposal 2-5-1 and Proposal 2-5-2 in R1-2405611; otherwise the UE capability of DCI0\_3/1\_3-based BWP switching is understood to have a per-FS granularity.*** |
| [5] | Samsung | FGs 49-12 and 49-12a were agreed in RAN1#117 to indicate UE support for unified TCI indication via DCI format 1\_3, as captured in the Moderator summary [1].  However, two clarifications are still needed for those FGs:   * Unlike the corresponding single-carrier FG 23-1-1b, the term “inter-cell” beam management is discarded from the name of FG 49-12. There was a comment that “inter-cell case should be further discussed as it is not clear whether it can be supported together with MC scheduling” [1]. It is noted that RAN1 has not agreed to any restriction for multi-cell scheduling to be limited to intra-band CA, including for any of the FG 49-n series. As can be seen from the prerequisites FG 49-1 and 49-1b, the only applicable constraint is to have same SCS and carrier type among the co-scheduled cells, which can be applicable for both intra-band CA and inter-band CA. In addition, unified TCI state indication can be combined with CC lists *simultaneousU-TCI-UpdateList1/2/3/4* that extend the indication well beyond intra-band CA. There is no motivation or need to limit FG 49-12 only to “intra-band” CA, hence the FG name should be updated. As a side note, there is no need to change the name of FG 49-12a, as the inter-band CA for that FG is already clarified to be possible, similar to the legacy FG 23-10-1b, when FG 23-10-1m is supported. * The description of component 1 of FGs 49-12 and FG 49-12a were intentionally left high-level and open-ended in RAN1#117 in anticipation of RAN1 decision in the maintenance session. Such progress was achieved in RAN1#117 and the following CR was agreed [2]. This CR clarifies a ‘DL assignment’ condition similar to that considered in the legacy FGs 23-1-1b and 23-10-1b for single-cell scheduling, and it can be reflected in the new FGs 49-12 and 49-12a for multi-cell scheduling.  |  | | --- | | **Excerpt from TS 38.214 v18.3.0 – 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*. The DCI format 1\_3 provides indicated *TCI state(s)* and/or*TCI-UL-State(s)* for the CC(s) in a *scheduledCellListDCI-1-3* if the UE is scheduled by the DCI format 1\_3 to receive PDSCH at least on one serving cell in the *scheduledCellListDCI-1-3*. The DCI format 1\_1/1\_2 can be with or without, if applicable, DL assignment. If the DCI format 1\_1/1\_2 is without DL assignment, the UE can assume |   **Proposal 1: FGs 49-12 and 49-12a are updated as follows:**   * **Update the name of FG 49-12 to include “inter-cell” beam management;** * **Clarify the DL assignment condition in Component 1 of both FGs 49-12/12a based on the CR agreed in [2];**  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 49-12 | Unified TCI with joint DL/UL TCI update by DCI format 1\_3 for intra-cell and inter-cell beam management with more than one MAC-CE activated joint TCI state per CC | 1: TCI state indication for update and activation   1. MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_3 with DL assignment for at least one serving cell in a *scheduledCellListDCI-1-3* to provide indicated unified TCI state(s) for the CC(s) in the *scheduledCellListDCI-1-3*)   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, at least one of {49-1, 49-1b} |  | Per Band | 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  Note: For component 2 and 3, same values as for FG23-1-1b are reported (if the UE also report FG23-1-1b) | Optional with capability signalling | | 49-12a | 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 activation   1. MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_3 with DL assignment for at least one serving cell in a *scheduledCellListDCI-1-3* to provide indicated unified TCI state(s) for the CC(s) in the *scheduledCellListDCI-1-3*)   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} |  | Per Band | 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  Candidate values of component 2: {n1, n2, n4, n7, n14, n28, n42, n56, n70, n84, n98, n112, n224, n336}  Candidate values of component 3: {2, …, 8}  Candidate values of component 4: {2, …, 8} | Optional with capability signalling | |
| [6] | Huawei, HiSilicon | **Default QCL assumption**  For cross-carrier scheduling, the UE capability FG18-5a was introduced in Rel-16 for UE to obtain the default QCL assumption when the TCI field is not present in DCI. For multi-cell scheduling, the TCI field may also be absent in DCI format 1\_3. However, in previous RAN1 discussions, cross-carrier scheduling and multi-cell scheduling with single DCI are considered as two separate features, and the support of DCI format 0\_3/1\_3 is feasible without the support of cross-carrier scheduling. Consequently, there is also a need to introduce the corresponding new FG for default QCL assumption for DCI format 1\_3.  **Proposal 1: Support FG49-13 to introduce default QCL assumption for DCI format 1\_3.**   |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 49-13 | Default QCL assumption for multi-cell scheduling | Indicates whether the UE can be configured with enabledDefaultBeamFormultiCellScheduling for default QCL assumption for multi-cell scheduling for same/different numerologies  - Candidate values are {different only, both}  - When "both" is reported, the UE supports this feature for same SCS and for different SCS combination(s) (low-to-high, high-to-low or both) reported for 49-1b | one of {49-1, 49-1b} |  |  |  | Per BC |  |  |  |  | |
| [7] | Ericsson | We would be OK to introduce a new FG for support of BWP switching with DCI formats 0\_3/1\_3 as it may also have other implications such as simultaneous BWP switching on multiple scheduled CCs (e.g. as raised in R1-2405791) as well as it aligns with handling of other features with DCI 0\_3/1\_3 such as cross-slot scheduling, etc. However, the granularity of these new FGs should also be per UE.  **For MCE, we propose the following:**   * 1. **Introduce a new FG for “BWP switching with same numerology by DCI format 0\_3/1\_3” with per UE granularity.**   2. **Introduce a new FG for “BWP switching with different numerology by DCI format 0\_3/1\_3” with per UE granularity.** |

## **Discussion**

### FG49-12/12a

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

**Update FG49-12/12a as below.**

* **Update the name of FG 49-12 to include “inter-cell” beam management**
* **Clarify the DL assignment condition in Component 1 of both FGs 49-12/12a as follows**
  + **“a) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_3 with DL assignment for at least one serving cell in a scheduledCellListDCI-1-3 to provide indicated unified TCI state(s) for the CC(s) in the scheduledCellListDCI-1-3)”**

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | **Summary of companies’ view:**   * Samsung: There is no motivation or need to limit FG 49-12 only to “intra-band” CA, hence the FG name should be updated. * Samsung: CR clarifies a ‘DL assignment’ condition similar to that considered in the legacy FGs 23-1-1b and 23-10-1b for single-cell scheduling, and it can be reflected in the new FGs 49-12 and 49-12a for multi-cell scheduling.   Reference:   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 49-12 | Unified TCI with joint DL/UL TCI update by DCI format 1\_3 for intra-cell beam management with more than one MAC-CE activated joint TCI state per CC | 1: TCI state indication for update and activation  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, At least one of {49-1, 49-1b} |  |  |  | Per band | 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  Note: For component 2 and 3, same values as for FG23-1-1b are reported (if the UE also report FG23-1-1b) | Optional with capability signaling | | 49-12a | 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 activation  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, At least one of {49-1, 49-1b} |  |  |  | Per band | 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  Candidate values of component 2: {n1, n2, n4, n7, n14, n28, n42, n56, n70, n84, n98, n112, n224, n336}  Candidate values of component 3: {2, …, 8}  Candidate values of component 4: {2, …, 8} | Optional with capability signaling | |
| Qualcomm | We are OK with the proposal. |
| OPPO | ok |
| vivo | Ok with the proposal. |
| NTT DOCOMO | We are OK with the proposal. |
| Huawei, HiSilicon | Ok to add ‘inter-cell’.  For the second clarification, we are not sure, as we think it is the intention to not add the restriction of “with DL assignment”. |
| ZTE | We are OK with the proposal. |
| Moderator (NTT DOCOMO) | Thanks for the inputs.  All companies are ok with first bullet, and all companies except Huawei/HiSilicon are also ok with second bullet.  We can check views/understandings on second bullet in online session. **Proposal 2-1:** **Update FG49-12/12a as below.**   * **Update the name of FG 49-12 to include “inter-cell” beam management** * **Clarify the DL assignment condition in Component 1 of both FGs 49-12/12a as follows**   + **“a) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_3 with DL assignment for at least one serving cell in a scheduledCellListDCI-1-3 to provide indicated unified TCI state(s) for the CC(s) in the scheduledCellListDCI-1-3)”** |

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

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

**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 or Per UE]
* Note
  + None
* Mandatory or optional
  + Optional with capability signaling

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

**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 or Per UE]
* Note
  + None
* Mandatory or optional
  + Optional with capability signaling

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | **Summary of companies’ view:**   * Support new FGs for BWP switching by DCI format 1\_3/0\_3: OPPO, Ericsson   + OPPO: The FG49-1 and FG49-2 indicating support of DCI 1\_3/0\_3 are defined per BC, while FG6-2/3/4 are defined per Band. So without new FGs as proposed in RAN1 #117, the logical combination of FG49-1/2 and FG6-2/3/4 gives a UE capability of DCI0\_3/1\_3-based BWP switching on a granularity of per Band and per Band-Combination, i.e., per feature-set, which goes more far away from the intention of simplifying the UE feature structure.   + OPPO: Without the new FGs as proposed in RAN1 #117, the following UE implementation combination (where UE observes different capabilities for DCI based BWP switching between legacy DCI and DCI 0\_3/1\_3), which may be preferred by UE vendors, would not be allowed:     - UE supports both BWP switching with ***same*** numerology and BWP switching with ***different*** numerologies (within a band) for DCI formats up to Rel-17; and meanwhile     - UE supports BWP switching with ***same*** numerology based on DCI 0\_3/1\_3, but has no capability for BWP switching with ***different*** numerologies based on DCI 0\_3/1\_3 (even though the UE may support FG49-1b for the BC’s).   + Ericsson: it may also have other implications such as simultaneous BWP switching on multiple scheduled CCs (e.g. as raised in R1-2405791) as well as it aligns with handling of other features with DCI 0\_3/1\_3 such as cross-slot scheduling, etc. However, the granularity of these new FGs should also be per UE. * Not support new FG for BWP switching by DCI format 1\_3/0\_3: ZTE   + 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. When DCI format 0\_2/1\_2 was introduced, it is natural to support BWP switching indicated by DCI format 0\_2/1\_2.   Reference:   |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 6-2 | Type A BWP adaptation with same numerology | 1) Up to 2 UE-specific RRC configured DL BWPs per carrier  2) Up to 2 UE-specific RRC configured UL BWPs per carrier  3) Active BWP switching by DCI and timer  4) Same numerology for all the UE-specific RRC configured BWPs per carrier  5) BW of a UE-specific RRC configured BWP includes BW of the CORESET#0 (if CORESET#0 is present) and SSB for PCell/PSCell (if configured) and BW of the UE-specific RRC configured BWP includes SSB for SCell if there is SSB on SCell | 6-1 | *upto2* in *bwp-SameNumerology* | *BandNR* | n/a | n/a |  | Optional with capability signalling | | 6-3 | Type B BWP adaptation with same numerology | 1) Up to 4 UE-specific RRC configured DL BWPs per carrier  2) Up to 4 UE-specific RRC configured UL BWPs per carrier  3) Active BWP switching by DCI and timer  4) Same numerology for all the UE-specific RRC configured BWPs per carrier  5) BW of a UE-specific RRC configured BWP includes BW of the CORESET#0 (if CORESET#0 is present) and SSB for PCell/PSCell (if configured) and BW of the UE-specific RRC configured BWP includes SSB for SCell if there is SSB on SCell | 6-1 | *upto4* in *bwp-SameNumerology* | *BandNR* | n/a | n/a |  | Optional with capability signalling | | 6-4 | BWP adaptation with different numerologies | 1) Up to 4 UE-specific RRC configured DL BWPs per carrier  2) Up to 4 UE-specific RRC configured UL BWPs per carrier  3) Active BWP switching by DCI and timer  4) More than one numerologies for the UE-specific RRC configured BWPs per carrier  5) Same numerology between DL and UL per cell except for SUL at a given time  6) BW of a UE-specific RRC configured BWP includes BW of the CORESET#0 (if CORESET#0 is present) and SSB for PCell/PSCell (if configured) and BW of the UE-specific RRC configured BWP includes SSB for SCell if there is SSB on SCell | 6-1 | *upto4* in *bwp-DiffNumerology* | *BandNR* | n/a | n/a |  | Optional with capability signalling | |
| Qualcomm | The BWP switching mechanism of DCI format 0\_3/1\_3 is different from legacy (e.g., the DCI 0\_3/1\_3 can indicate BWP switch for some cells and BWP stay for other cells based on validity/invalidity of FDRA fields). Therefore, we agree having new FG makes sense.  However, we think BWP-switching capability should still be based on 6-2, 6-3, or 6-4. Otherwise, the new FG looks new FG defines new BWP-switching FG. Rather, the new FG should be to indicate support BWP switching by DCI format 0\_3/1\_3.  Given this, we suggest following.  **Introduce following FG that indicates support of BWP switch by DCI format 0\_3/1\_3.**   * FG name   + Support of BWP switch indication by DCI format 0\_3/1\_3 * Component   + Support of BWP switch indication by DCI format 0\_3/1\_3 * Prerequisite   + At least one of {49-1, 49-1b, 49-2, 49-2b} for the BC   + At least one of {6-2, 6-3, 6-4} for at least one band of the BC * Type   + Per BC * Note   + None * Mandatory or optional   + Optional with capability signaling |
| OPPO | We support having new FG, and are ok to the proposals 2-2-1 and 2-2-2 (both in “per BC” granularity). We are also partially ok to Qualcomm’s proposal, with the concern on putting “same numerology” and “different numerology” in the same FG -- We think the “same numerology” and “different numerology” should belong to different FGs, because the following combination of prerequisites means nothing.   * Prerequisite   + At least one of {49-1, 49-1b, 49-2, 49-2b} for the BC => this support can be only for “same numerology”   + At least one of {6-2, 6-3, 6-4} for at least one band of the BC => this support may be only for “different numerology” (although this can be rare, but it is allowed) |
| vivo | We prefer to have separate FGs for same SCS and different SCS, considering that mc scheduling with mixed SCS and same SCS are defined with different capabilities.  We also suggest to refine the FG name to make it clearer **Proposal 2-2-1:** **Introduce following FG for BWP switching between one or more BWPs with same numerology by DCI format 0\_3/1\_3.**   * FG name   + BWP switching **between one or more BWPs** with same numerology by DCI format 0\_3/1\_3 * Component   + Support of BWP switching **between one or more BWPs** with same numerology by DCI format 0\_3/1\_3  **Proposal 2-2-2:** **Introduce following FG for BWP switching between one or more BWPs with different numerology by DCI format 0\_3/1\_3.**   * FG name   + BWP switching with **between one or more BWPs** different numerology by DCI format 0\_3/1\_3 * Component   + Support of BWP switching **between one or more BWPs** with different numerology by DCI format 0\_3/1\_3 * Prerequisite   + At least one of {~~49-1,~~ 49-1b, ~~49-2,~~ 49-2b}---》49-1b, 49-2b are for mixed SCS, thus should be the prerequisite, not sure why 49-1 and 49-2 for same SCS case are included   Regarding {6-2, 6-3, 6-4}, if {6-2, 6-3, 6-4} has to be included as prerequisite, we assume that 6-2, 6-3 are for same SCS BWP switching by mc-DCI, 6-4 is for mixed SCS BWP switching by mc-DCI  Regarding granularity, per BC is ok. |
| NTT DOCOMO | We support new FG(s) for BWP switching by DCI format 1\_3/0\_3.  We also agree with Qualcomm’s comment that 6-2/3/4 are used to indicate BWP-switching capability and could be prerequisite for the new FG for BWP-switching by DCI format 0\_3/1\_3.  We think that even with single new FG, the support of BWP-switching with same numerology or different numerology can be clarified by prerequisite FGs, e.g., only when UE supports {49-1b or 49-2b}, 6-4 and new FG, the UE is capable of BWP-switching with different numerology by DCI format 0\_3/1\_3.  Regarding reporting granularity, we are fine with per BC. |
| Huawei, HiSilicon | Support to have new FGs with per BC granularity. |
| ZTE | As discussion in our contribution, we don’t see the need to introduce a UE capability here. |
| Moderator (NTT DOCOMO) | Thanks for the inputs.  The majority is ok to have new FG(s) for support of BWP switching indication by DCI format 0\_3/1\_3, while there are two possible approaches to introduce new FG(s), such as single FG or separate FGs for same numerology case and different numerology case.  So, we need to discuss two alternative proposals in online session.  Alt.1: single FG approach **Proposal 2-2-1:** **Introduce following FG that indicates support of BWP switch by DCI format 0\_3/1\_3.**   * FG name   + Support of BWP switch indication by DCI format 0\_3/1\_3 * Component   + Support of BWP switch indication by DCI format 0\_3/1\_3 * Prerequisite   + At least one of {49-1, 49-1b, 49-2, 49-2b} for the BC   + At least one of {6-2, 6-3, 6-4} for at least one band of the BC * Type   + Per BC * Note   + Note: only when UE supports {49-1b or 49-2b}, 6-4 and new FG, the UE is capable of BWP-switching with different numerology by DCI format 0\_3/1\_3 * Mandatory or optional   + Optional with capability signaling   Alt.2: separate FGs approach **Proposal 2-2-1:** **Introduce following FG for BWP switching with same numerology by DCI format 0\_3/1\_3.**   * FG name   + BWP switching **between one or more BWPs** with same numerology by DCI format 0\_3/1\_3 * Component   + Support of BWP switching **between one or more BWPs** with same numerology by DCI format 0\_3/1\_3 * Prerequisite   + At least one of {49-1, 49-1b, 49-2, 49-2b} for the BC   + At least one of {6-2, 6-3} for at least one band of the BC * Type   + Per BC * Note   + None * Mandatory or optional   + Optional with capability signaling  **Proposal 2-2-2:** **Introduce following FG for BWP switching with different numerology by DCI format 0\_3/1\_3.**   * FG name   + BWP switching **between one or more BWPs** with different numerology by DCI format 0\_3/1\_3 * Component   + Support of BWP switching **between one or more BWPs** with different numerology by DCI format 0\_3/1\_3 * Prerequisite   + At least one of {49-1b, 49-2b} for the BC   + 6-4 for at least one band of the BC * Type   + Per BC * Note   + None * Mandatory or optional   + Optional with capability signaling |

### default QCL assumption for multi-cell scheduling

#### **Proposal 2-3:**

**Introduce following FG for default QCL assumption for multi-cell scheduling.**

* FG name
  + Default QCL assumption for multi-cell scheduling
* Component
  + Indicates whether the UE can be configured with enabledDefaultBeamFormultiCellScheduling for default QCL assumption for multi-cell scheduling for same/different numerologies
    - Candidate values are {different only, both}
      * When "both" is reported, the UE supports this feature for same SCS and for different SCS combination(s) (low-to-high, high-to-low or both) reported for 49-1b
* Prerequisite
  + At least one of {49-1, 49-1b}
* Type
  + Per BC
* Note
  + None
* Mandatory or optional
  + Optional with capability signaling

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | **Summary of companies’ view:**   * Huawei/HiSilicon: cross-carrier scheduling and multi-cell scheduling with single DCI are considered as two separate features, and the support of DCI format 0\_3/1\_3 is feasible without the support of cross-carrier scheduling. Consequently, there is also a need to introduce the corresponding new FG for default QCL assumption for DCI format 1\_3.   Reference:   |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 18. MR-DC/CA enhancement | 18-5a | Default QCL assumption for cross-carrier scheduling | Indicates whether the UE can be configured with enabledDefaultBeamForCCS for default QCL assumption for cross-carrier scheduling for same/different numerologies  - Candidate values are {different only, both}  - When "both" is reported, the UE supports this feature for same SCS and for different SCS combination(s) (low-to-high, high-to-low or both) reported for 18-5 | one of {6-10, 18-5} | *crossCarrierSchedulingDefaultQCL-r16* | *CA-ParametersNR-v1610* | n/a | n/a |  | Optional with capability signalling | |
| Qualcomm | We agree with the proposal. |
| OPPO | ok to proposal. We suggest to mention DCI 1\_3 in FG name and component description:   * FG name   + Default QCL assumption for multi-cell scheduling by DCI 1\_3 * Component   + Indicates whether the UE can be configured with enabledDefaultBeamFormultiCellScheduling for default QCL assumption for multi-cell scheduling by DCI 1\_3 for same/different numerologies |
| vivo | Support OPPO’s updates |
| NTT DOCOMO | We are OK with the proposal and OPPO’s suggested update. |
| Huawei, HiSilicon | Support |
| ZTE | We are fine with the OPPO’s update. |
| Moderator (NTT DOCOMO) | Thanks for the inputs.  All companies are basically ok with the proposal, and multiple companies support OPPO’s suggested update which should be fine for other companies as well.  So, the proposal is to agree on following updated proposal. **Updated proposal 2-3:** **Introduce following FG for default QCL assumption for multi-cell scheduling.**   * FG name   + Default QCL assumption for multi-cell scheduling by DCI format 1\_3 * Component   + Indicates whether the UE can be configured with enabledDefaultBeamFormultiCellScheduling for default QCL assumption for multi-cell scheduling by DCI format 1\_3 for same/different numerologies     - Candidate values are {different only, both}       * When "both" is reported, the UE supports this feature for same SCS and for different SCS combination(s) (low-to-high, high-to-low or both) reported for 49-1b * Prerequisite   + At least one of {49-1, 49-1b} * Type   + Per BC * Note   + None * Mandatory or optional   + Optional with capability signaling |

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

No inputs are provided in contributions for the RAN1#118 meeting.

# **Conclusions**

TBD

# **References**

[1] R1-2405564 Updated RAN1 UE features list for Rel-18 NR after RAN1#117 Moderators (AT&T, NTT DOCOMO, INC.)

[2] R1-2405611 Summary#2 of discussion on UE features for MC enhancements Moderator (NTT DOCOMO, INC.)

[3] R1-2405932 Discussion on UE feature for topics A ZTE Corporation, Sanechips

[4] R1-2406225 Discussion on UE features for multi-carrier enhancement OPPO

[5] R1-2406635 UE features for other Rel-18 work items (Topics A) Samsung

[6] R1-2406980 UE features for other Rel-18 work items (Topics A) Huawei, HiSilicon

[7] R1-2407161 Rel-18 UE features topics set A Ericsson

# **Appendix: UE features list for Rel-18 NR\_MC\_enh [1]**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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".  For component 6, same values as for FG11-4 are reported (if the UE also report FG11-4) | 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.  For component 6, same values as for FG11-4a are reported (if the UE also report FG11-4a) | 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}  For component 4 and 5, same values as for FG12-1 are reported (if the UE also report FG12-1) | 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 | 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  For component 3 and 4, same values as for FG25-7 are reported (if the UE also report FG25-7) | 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 | 49-11 | PHY priority indication 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 | 49-5a and 49-6 |  |  |  | Per UE | No | No | N/A |  | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-12 | Unified TCI with joint DL/UL TCI update by DCI format 1\_3 for intra-cell beam management with more than one MAC-CE activated joint TCI state per CC | 1: TCI state indication for update and activation  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, At least one of {49-1, 49-1b} |  |  |  | Per band | 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  Note: For component 2 and 3, same values as for FG23-1-1b are reported (if the UE also report FG23-1-1b) | Optional with capability signaling |
| 49. NR\_MC\_enh | 49-12a | 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 activation  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, At least one of {49-1, 49-1b} |  |  |  | Per band | 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  Candidate values of component 2: {n1, n2, n4, n7, n14, n28, n42, n56, n70, n84, n98, n112, n224, n336}  Candidate values of component 3: {2, …, 8}  Candidate values of component 4: {2, …, 8} | 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 |