**3GPP TSG RAN WG1 #112bis-e R1-2303987**

**e-Meeting, April 17th – April 26th, 2023**

**Agenda item:** 7.2

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

**Title:** Summary#1 on UE features for NR MBS

**Document for:** Discussion and Decision

# **Introduction**

This document summarizes contributions submitted to AI 7.2 regarding UE features for NR MBS and captures company views based on the announcement in the following email thread.

|  |
| --- |
| [112bis-e-R17-UE\_features-01] Email discussion on remaining details of Rel-17 MBS UE features by April 21 – Hiroki (DOCOMO) |

Based on the latest RAN1 UE features list on Rel-17 NR MBS in [1] and the contributions, there is only one remaining issue on FG33-5-1a with yellow-highlighted part as below.

|  |  |  |  |
| --- | --- | --- | --- |
| 33. NR\_MBS | 33-5-1a | Support of ACK/NACK based HARQ-ACK feedback and RRC-based enabling/disabling ACK/NACK-based feedback for SPS group-common PDSCH for multicast | 1. Support of ACK/NACK based HARQ-ACK feedback, and support of enabling/disabling ACK/NACK based HARQ-ACK feedback configured by RRC signalling for SPS group-common PDSCH without PDCCH scheduling, [SPS group-common PDSCH activation]  2. Support of PTM retransmission for SPS multicast associated with G-CS-RNTI  3. Support of Type-1 and Type-2 HARQ-ACK CB for SPS multicast feedback only  4. Support of shared SPS-PUCCH-AN-List configuration from unicast SPS |

# **Discussion on UE features for NR MBS**

## **2.1 Brackets on component 1 of FG33-5-1a**

In [1], FG 33-5-1a is captured as below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 33. NR\_MBS | 33-5-1a | Support of ACK/NACK based HARQ-ACK feedback and RRC-based enabling/disabling ACK/NACK-based feedback for SPS group-common PDSCH for multicast | 1. Support of ACK/NACK based HARQ-ACK feedback, and support of enabling/disabling ACK/NACK based HARQ-ACK feedback configured by RRC signalling for SPS group-common PDSCH without PDCCH scheduling, [SPS group-common PDSCH activation]  2. Support of PTM retransmission for SPS multicast associated with G-CS-RNTI  3. Support of Type-1 and Type-2 HARQ-ACK CB for SPS multicast feedback only  4. Support of shared SPS-PUCCH-AN-List configuration from unicast SPS | 33-5-1 | Yes |  |  | Per BC | N/A | N/A |  |  | Optional with capability signalling |

As summarized in [2], this issue has been discussed in previous meetings, but it is still unsolved.

Following views are provided in contributions for the RAN1#112bis-e meeting.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| [3] | Huawei, HiSilicon | Whether the disabling HARQ-ACK applied to the first PDSCH after SPS activation is controversial and was discussed several meetings yet with no consensus. Based on the current specification, the interpretation is that the first PDSCH after SPS activation is also one PDSCH so that the disabling HARQ-ACK is applied complying to the specification description.   |  | | --- | | ***18 Multicast Broadcast Services***  *….*  *A UE can be configured per G-RNTI for multicast or per G-CS-RNTI, by* *harq-FeedbackEnablerMulticast with value set to ‘enabled’, to provide HARQ-ACK information for PDSCH receptions.* ***When the UE is not provided harq-FeedbackEnablerMulticast*** *for a G-RNTI for multicast or G-CS-RNTI and pdsch-HARQ-ACK-Codebook = dynamic for multicast HARQ-ACK information,* ***the UE does not provide HARQ-ACK information for respective PDSCH receptions.*** *If a UE is provided harq-FeedbackEnablerMulticast with value set to ‘dci-enabler’ for a G-RNTI for multicast or a G-CS-RNTI, the UE provides HARQ-ACK information for PDSCH receptions scheduled by multicast DCI format 4\_1 associated with the G-RNTI or the G-CS-RNTI, and determines whether or not to provide the HARQ-ACK information for PDSCH receptions scheduled by multicast DCI format 4\_2 based on an indication by the multicast DCI format 4\_2 associated with the G-RNTI for multicast or the G-CS-RNTI [4, TS 38.212]. If a UE is provided pdsch-HARQ-ACK-Codebook = semi-static for multicast HARQ-ACK information, the UE does not expect to be provided harq-FeedbackEnablerMulticast with value set to ‘dci-enabler’ for a G-RNTI or a G-CS-RNTI.*  *…..* |   With no CR for the current specification, the bracket in component 1 of FG33-5-1a can be removed but with the content within the bracket kept. It would be more accurate to change ‘SPS group-common PDSCH activation’ to ‘the first PDSCH after an activation of SPS PDSCH receptions’. Note the similar change is needed for FG33-5-1f.  The main concern for no HARQ-ACK information for the first PDSCH after SPS activation is the DCI missing by UE is not aware by network and the subsequent SPS PDSCH transmissions will be wasted in such a case. As discussed in the discussion paper [2], when the parameter of ‘*harq-feedbackEnablingforSPSactive*’ is ‘enabled’, UE will report HARQ-ACK for the first PDSCH after SPS activation when UE is provided *downlinkHARQ-FeedbackDisabled.* In addition, the parameter of *harq-feedbackEnablingforSPSactive* with the following generic descriptionfrom TS 38.331 can be configured to UE supporting MBS but not NTN as long as UE supports such function, defining an additional UE feature into the MBS UE feature list can be considered for a way forward.   |  | | --- | | ***Harq-FeedbackEnablingforSPSactive***  *If enabled, UE reports ACK/NACK for the first SPS PDSCH after activation, regardless of if HARQ feedback is enabled or disabled corresponding to the first SPS PDSCH after activation. Otherwise, UE follows configuration of HARQ feedback enabled/disabled corresponding to the first SPS PDSCH after activation.* |   To this end, the additional UE feature can be added as e.g., FG33-5-1c as below proposed.  ***Proposal: Updating 33-5-1a/1f and adding FG33-5-1c as follows in red:***   |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 33. NR\_MBS | 33-5-1a | Support of ACK/NACK based HARQ-ACK feedback and RRC-based enabling/disabling ACK/NACK-based feedback for SPS group-common PDSCH for multicast | 1. Support of ACK/NACK based HARQ-ACK feedback, and support of enabling/disabling ACK/NACK based HARQ-ACK feedback configured by RRC signalling for SPS group-common PDSCH without PDCCH scheduling and the first PDSCH after an activation of SPS PDSCH receptions ~~[SPS group-common PDSCH activation]~~  2. Support of PTM retransmission for SPS multicast associated with G-CS-RNTI  3. Support of Type-1 and Type-2 HARQ-ACK CB for SPS multicast feedback only  4. Support of shared SPS-PUCCH-AN-List configuration from unicast SPS | 33-5-1 | Yes |  |  | Per BC | N/A | N/A |  |  | Optional with capability signalling | | 33. NR\_MBS | 33-5-1c | Support of separate enabling HARQ-ACK for the first PDSCH after SPS activation | 1. support a separate enabling HARQ-ACK for the first PDSCH after SPS activation regardless of whether UE is provided with disabling HARQ-ACK for a G-CS-RNTI. | 33-5-1a or 33-5-1f | Yes |  |  | Per BC | N/A | N/A |  |  | Optional with capability signalling | | 33. NR\_MBS | 33-5-1f | NACK-only based HARQ-ACK feedback for multicast RRC-based enabling/disabling NACK-only based feedback for SPS group-common PDSCH for multicast | 1. Support NACK-only based HARQ-ACK feedback, and support of enabling/disabling NACK-only based HARQ-ACK feedback configured by RRC signalling for SPS group-common PDSCH without PDCCH scheduling and the first PDSCH after an activation of SPS PDSCH receptions   a) A single TB with NACK-only feedback transmitted in PUCCH  b) multiple TBs with NACK-only feedback transmitted in PUCCH by transforming into ACK/NACK bits  2) Support of shared PUCCH resource configurations with unicast  3) One or multiple TB with NACK-only feedback transmitted in PUSCH by transforming into ACK/NACK bits  4) One or multiple TB with NACK-only feedback transmitted in PUCCH by transforming into ACK/NACK bits when multiplexing with other UCI | 33-5-1a | Yes |  |  | Per BC | N/A | N/A |  |  | Optional with capability signalling | |
| [4] | ZTE | In RAN1#112 meeting, companies had different views on whether UE is allowed to indicate support or not of enabling/disabling ACK/NACK based HARQ-ACK feedback configured by RRC signalling for SPS group-common PDSCH activation. From network perspective, the ACK/NACK for SPS group-common PDSCH activation is important to align the understanding on SPS activation between gNB and UE. Thus, we have the following proposal.  ***Proposal 1****: Update the UE feature 33-5-1a for R17 MBS as follows.*   |  |  |  |  |  | | --- | --- | --- | --- | --- | | 33. NR\_MBS | 33-5-1a | Support of ACK/NACK based HARQ-ACK feedback and RRC-based enabling/disabling ACK/NACK-based feedback for SPS group-common PDSCH for multicast | 1. Support of ACK/NACK based HARQ-ACK feedback, and support of enabling/disabling ACK/NACK based HARQ-ACK feedback configured by RRC signalling for SPS group-common PDSCH without PDCCH scheduling~~, [SPS group-common PDSCH activation]~~  2. Support of PTM retransmission for SPS multicast associated with G-CS-RNTI  3. Support of Type-1 and Type-2 HARQ-ACK CB for SPS multicast feedback only  4. Support of shared SPS-PUCCH-AN-List configuration from unicast SPS | 33-5-1 | |
| [5] | Qualcomm Incorporated | We suggest the following changes for the remaining FFSs of FG33-5-1, FG33-5-1x and FG33-5-2 as   |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 33. NR\_MBS | 33-5-1 | SPS group-common PDSCH for multicast on Pcell | 1. Support one SPS group-common PDSCH configuration for multicast  2. Support {2, 4, 8} times semi-static slot-level repetition for SPS group-common PDSCH  3. Support of group-common PDCCH/PDSCH with CRC scrambled by G-CS-RNTI(s) for multicast  4. Support of DCI format 4\_1 with CRC scrambled with G-CS-RNTI for multicast  5. ACK/NACK-based HARQ-ACK feedback for SPS release associated with G-CS-RNTI  6. ACK/NACK-based HARQ-ACK feedback for first PDSCH after SPS activation associated with G-CS-RNTI | 33-2 | Yes |  |  | Per FS | N/A | N/A |  | one G-CS-RNTI per UE is supported for multicast reception | Optional with capability signalling | | 33. NR\_MBS | 33-5-1a | Support of ACK/NACK based HARQ-ACK feedback and RRC-based enabling/disabling ACK/NACK-based feedback for SPS group-common PDSCH for multicast | 1. Support of ACK/NACK based HARQ-ACK feedback, and support of enabling/disabling ACK/NACK based HARQ-ACK feedback configured by RRC signalling for SPS group-common PDSCH without PDCCH scheduling  2. Support of PTM retransmission for SPS multicast associated with G-CS-RNTI  3. Support of Type-1 and Type-2 HARQ-ACK CB for SPS multicast feedback only  4. Support of shared SPS-PUCCH-AN-List configuration from unicast SPS | 33-5-1 | Yes |  |  | Per BC | N/A | N/A |  |  | Optional with capability signalling | |

In addition, as pointed in [3], this issue is also discussed for CR for TS38.213, and there are number of proposed draft CRs on this issue in AI 7.2 as well [6-11].

Based on contributions [3-11], companies’ views can be summarized as below.

* For ACK/NACK based HARQ-ACK feedback and RRC-based enabling/disabling ACK/NACK-based feedback for SPS group-common PDSCH for multicast,
  + Alt.1: Disabling ACK/NACK based HARQ-ACK feedback configured by RRC signaling for SPS group-common PDSCH (via *harq-FeedbackEnablerMulticast*) is not applied to the first PDSCH after SPS activation, and ACK/NACK based HARQ-ACK feedback is always enabled for the first PDSCH after SPS activation, i.e., [SPS group-common PDSCH activation] is removed from component 1 of FG33-5-1a and “ACK/NACK-based HARQ-ACK feedback for first PDSCH after SPS activation associated with G-CS-RNTI” is added as new component of FG33-5-1 (same as SPS release)
    - Supported by Qualcomm, [ZTE], [vivo], [CATT], [MTK]
  + Alt.2: Enabling/disabling ACK/NACK based HARQ-ACK feedback for the first PDSCH after SPS activation follows *harq-feedbackEnablingforSPSactive* if configured, i.e., [SPS group-common PDSCH activation] is replaced by “first PDSCH after SPS activation” in component 1 of FG33-5-1a
    - Supported by Huawei/HiSilicon, [NTT DOCOMO], [Qualcomm (as compromise)]
    - Huawei/HiSilicon also propose to introduce a new FG for “support of separate enabling HARQ-ACK for the first PDSCH after SPS activation”
* For NACK-only based HARQ-ACK feedback and RRC-based enabling/disabling NACK-only based feedback for SPS group-common PDSCH for multicast,
  + Huawei/HiSilicon propose to adopt same update as for FG33-5-1a to FG33-5-1f, i.e., “and the first PDSCH after an activation of SPS PDSCH receptions” is added in component 1 of FG33-5-1f in case of Alt.2 for FG33-5-1a

As in previous meetings, it is moderator’s understanding that we should wait for the outcome of maintenance discussion on corresponding CRs. Therefore, the moderator would like to provide a proposal based on the outcome of maintenance discussion on corresponding CRs once it becomes ready.

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

**The component 1 of FG33-5-1a is updated as below.**

* **1. Support of ACK/NACK based HARQ-ACK feedback, and support of enabling/disabling ACK/NACK based HARQ-ACK feedback configured by RRC signalling for SPS group-common PDSCH without PDCCH scheduling and first PDSCH after SPS activation**

|  |  |
| --- | --- |
| Company | Comment |
| DCM | We agree that discussion should be pending until CR discussion is concluded.  Besides, HW’s proposal of NACK-only feedback for the initial SPS PDSCH after activation seems to be invalid/unnecessary since NACK-only feedback is not applicable for the PDSCH as follows from 213:   |  | | --- | | For the second HARQ-ACK reporting mode, the UE does not transmit a PUCCH that would include only HARQ-ACK information with ACK values. **The second HARQ-ACK reporting mode is not applicable for the first SPS PDSCH reception after activation of SPS PDSCH receptions for a SPS configuration**, or for DCI formats having associated HARQ-ACK information without scheduling a PDSCH reception. | |
| Qualcomm | Agree with DCM.  In addition, we think a new FG may not be needed for Alt2. |
| Huawei, HiSilicon | For ACK/NACK based, the change to FG33-5-1a can wait.  We’d like to clarify and acknowledge that the change suggested for NACK-only based is indeed not needed since NACK-only is not applied to the SPS activation anyway. |
| Moderator (NTT DOCOMO) | Thank you very much for your feedbacks!  Based on the feedbacks, we can focus on ACK/NACK based case and anyway we should wait for the outcome of corresponding discussion on CR. |
| Moderator (NTT DOCOMO) | In the CR discussion, following conclusion was made.  **Issue (1-9) Disabled HARQ-ACK not applied to SPS activation**  No consensus to change the specs. The common understanding in RAN1 on the current specifications is that disabling HARQ-ACK (when configured) applies to the first PDSCH after SPS activation.  Therefore,what we should do for FG33-5-1a would be removing bracket and updating the text to “first PDSCH after SPS activation” as below. **Proposal 2-1:** **The component 1 of FG33-5-1a is updated as below.**   * **1. Support of ACK/NACK based HARQ-ACK feedback, and support of enabling/disabling ACK/NACK based HARQ-ACK feedback configured by RRC signalling for SPS group-common PDSCH without PDCCH scheduling and first PDSCH after SPS activation** |
| Huawei, HiSilicon | ok |
|  |  |

# **Conclusions**

TBD

# **References**

[1] R1-2302024 Updated RAN1 UE features list for Rel-17 NR after RAN1 #112 Moderators (AT&T, NTT DOCOMO, INC.)

[2] R1-2302023 Summary#3 on UE features for NR MBS Moderator (NTT DOCOMO, INC.)

[3] R1-2302344 Remaining issues for Rel-17 MBS UE features. Huawei, HiSilicon

[4] R1-2302755 Remaining issues for MBS UE feature ZTE

[5] R1-2303572 Discussion on Rel-17 UE features Qualcomm Incorporated

[6] R1-2302462 Draft CR on not applying disabled HARQ-ACK to multicast SPS PDSCH activation/deactivation vivo

[7] R1-2302659 Draft CR on not applying enabled/disabled HARQ-ACK feedback to multicast SPS activation/deactivation CATT

[8] R1-2303570 Draft CR on feedback for first PDSCH after multicast SPS activation Qualcomm Incorporated

[9] R1-2303637 Correction on HARQ-ACK for multicast SPS MediaTek Inc.

[10] R1-2303696 Draft CR on HARQ feedback for the initial SPS PDSCH NTT DOCOMO, INC.

[11] R1-2303793 Draft CR on disabling HARQ-ACK for multicast SPS Huawei, HiSilicon, CBN

# **Appendix: Latest RAN1 UE features list for Rel-17 NR MBS in R1-2302024**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 |
| 33. NR\_MBS | 33-1 | Broadcast | 1. Support of group-common PDCCH/PDSCH for broadcast with CRC scrambled by MCCH-RNTI.  2. Support of group-common PDCCH/PDSCH for broadcast with CRC scrambled by G-RNTI(s) for MTCH.  3. Support of CFR configuration for broadcast.  4. Support of CORESET and common search space for broadcast.  5. Support of DCI format 4\_0 with CRC scrambled with G-RNTI/MCCH-RNTI for broadcast.  6. Support of inter-slot TDM between unicast PDSCH and MCCH group-common PDSCH or MTCH group-common PDSCH, or between MCCH group-common PDSCH and MTCH group-common PDSCH, or among unicast PDSCH and MCCH group-common PDSCH and MTCH group-common PDSCH in different slots.  7. Support MCCH change notification indication via DCI.  8. support of higher layer configured slot-level repetition up to 8 for MTCH  9. One G-RNTI per UE is supported for broadcast reception  10. Support of FDMed MCCH and PBCH  11. Support of up to 64QAM for FR1/FR2 |  | Up to RAN2 |  |  | Up to RAN2 | Up to RAN2 | Up to RAN2 |  | It is up to RAN2 whether/how to introduce the capability for support of N > 1 G-RNTIs for broadcast for a UE | Optional without capability signalling |
| 33. NR\_MBS | 33-1-1 | DCI indicated slot-level repetition up to 16 for broadcast MTCH | Support up to 16 times dynamic slot-level repetition for broadcast MTCH. | 33-1 | Up to RAN2 |  |  | Per FSPC | N/A | N/A |  |  | Up to RAN2 |
| 33. NR\_MBS | 33-1-2 | FDM-ed unicast PDSCH and group-common PDSCH for broadcast | 1. Support FDM between one unicast PDSCH and one group-common PDSCH for broadcast in RRC CONNECTED mode in a slot. | 33-1 | Yes |  |  | Per FSPC | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-2 | Dynamic scheduling for multicast for PCell | 1. Support of group-common PDCCH/PDSCH for multicast with CRC scrambled by G-RNTI for PCell.  2. Support of CFR configuration for multicast.  3. Support of CORESET and common search space configuration for multicast.  4. Support of DCI format 4\_1 with CRC scrambled with G-RNTI for multicast.  5. Support of inter-slot TDM between group-common PDSCH for multicast and other PDSCHs in different slots.  6. Support {2, 4, 8} times semi-static slot-level repetition for group-common PDSCH for multicast |  | Yes |  |  | Per FS | N/A | N/A |  | one G-RNTI per UE is supported for multicast reception | Optional with capability signalling |
| 33. NR\_MBS | 33-2a | Support of ACK/NACK based HARQ-ACK feedback andRRC-based enabling/disabling ACK/NACK-based feedback for dynamic scheduling for multicast | 1) Support of ACK/NACK based HARQ-ACK feedback, and support of enabling/disabling ACK/NACK based HARQ-ACK feedback configured by RRC signalling  2) Support of PTM retransmission for multicast  3) support of Type-1 and Type-2 HARQ-ACK CB for multicast feedback only  4) Support of shared PUCCH resource configurations with unicast  5) Support of Type-2 HARQ-ACK codebook for multicast on PUSCH/PUCCH with max number X of G-RNTIs | 33-2 | Yes |  |  | Per BC | N/A | N/A |  | Candidate values of X is {1, 2, 3, 4} with X no larger than max number of G-RNTIs of FG33-2e  Note: the value of X should be common across FG33-2a, 33-3-3a and 33-3-3b if reported | Optional with capability signalling |
| 33. NR\_MBS | 33-2b | DCI-based enabling/disabling ACK/NACK-based feedback for dynamic scheduling for multicast | Support of DCI-based enabling/disabling ACK/NACK based HARQ-ACK feedback configured per G-RNTI by RRC signaling via DCI format 4\_2 | 33-2a, 33-2f | Yes |  |  | Per band | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-2d | PTP retransmission for multicast dynamic scheduling | Support of PTP retransmission for multicast on the same cell as multicast initial transmission | 33-2a | Yes |  |  | Per BC | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-2e | Multiple G-RNTIs for group-common PDSCHs | Capability on number of G-RNTI for multicast | 33-2 | Yes |  |  | Per UE | [Yes] | Yes |  | Reporting type of FG 33-2e is per UE with [FDD/TDD,] FR1/FR2, licensed/unlicensed, and TN/NTN differentiation, detail signalling is up to RAN2 | Optional with capability signalling |
| 33. NR\_MBS | 33-2f | Dynamic multicast with DCI format 4\_2 | Support of DCI format 4\_2 with CRC scrambled with G-RNTI for multicast | 33-2 | Yes |  |  | Per band | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-2g | MIMO layers for multicast PDSCH | Supported maximal number of MIMO layers for multicast PDSCH | 33-2 | Yes |  | UE supports 1 MIMO layer only for multicast PDSCH | Per FSPC | N/A | N/A |  | Candidate values: {2,4,8}  Note: If UE supports up to 8 layers, the UE supports TB2 | Optional with capability signalling |
| 33. NR\_MBS | 33-2h | Dynamic scheduling for multicast for SCell | Support of group-common PDCCH/PDSCH with CRC scrambled by G-RNTI for SCell. | 33-2 | Yes |  |  | Per FSPC | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-2i | Supported maximal modulation order for multicast PDSCH | 1. For FR1, up to 1024QAM is supported, candidate values {256QAM, 1024QAM}  2. For FR2, up to 256QAM is supported, candidate values {64QAM, 256QAM} | 33-2 | Yes |  | The UE supports the same modulation order as unicast | Per band | N/A | N/A |  | Note: A UE shall support the corresponding mandatory maximum modulation for unicast. | Optional with capability signalling |
| 33. NR\_MBS | 33-2j | Supported maximum modulation order used for maximum data rate calculation for multicast PDSCH | 1. For FR1, up to 1024QAM is supported as maximum modulation order used for maximum data rate calculation for multicast PDSCH, candidate values {256QAM, 1024QAM}  2. For FR2, up to 256QAM is supported as maximum modulation order used for maximum data rate calculation for multicast PDSCH, candidate values {64QAM, 256QAM} | 33-2 | Yes |  |  | Per FSPC | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-3-1 | Dynamic Slot-level repetition for group-common PDSCH | 1. Support up to X times dynamic slot-level repetition for group-common PDSCH for multicast. | 33-2 | Yes |  |  | Per UE | Yes | Yes |  | Candidate values for X is: {8, 16}  This FG is reported for TN and licensed. | Optional with capability signalling |
| 33. NR\_MBS | 33-3-1a | Dynamic Slot-level repetition for group-common PDSCH for NTN and unlicensed | 1. Support up to X times dynamic slot-level repetition for group-common PDSCH for multicast for NTN and unlicensed | 33-2 | Yes |  |  | Per band | N/A | N/A |  | Candidate values for X is: {8, 16}  This FG is reported for NTN and unlicensed | Optional with capability signalling |
| 33. NR\_MBS | 33-3-2 | FDM-ed unicast PDSCH and one group-common PDSCH for multicast | 1. Support FDM between one dynamically scheduled unicast PDSCH and one dynamically scheduled group-common PDSCH for multicast in RRC CONNECTED mode in a slot. | 33-2, or at least one of {33-5-1a, 33-5-1f} | Yes |  |  | Per FSPC | N/A | N/A |  | Note: this FG does not support FDMed SPS | Optional with capability signalling |
| 33. NR\_MBS | 33-3-3 | Intra-slot TDM-ed unicast PDSCH and group-common PDSCH | 1. Support TDM between one unicast PDSCH and one group-common PDSCH in a slot.  2. Support TDM between M (M>1) TDMed unicast PDSCHs and one group-common PDSCH in a slot per CC  3. Support TDM among N (N>1) group-common PDSCHs in a slot per CC  4. Support TDM between K (K>1) TDMed unicast PDSCHs and L (L>1) TDMed group-common PDSCHs in a slot per CC  5. The UE maximum number of TDMed PDSCH receptions capability in a slot per CC is kept as for Rel-15/Rel-16, i.e., {2/4/7} based on UE FG5-11/5-11a/5-11b.   * + Note:  Group-common PDSCH(s) are counted as unicast PDSCH(s).   + Note: The max number of (M+1), N, (K+L) are determined based on the numbers reported by FG5-11 and/or FG5-11a and/or FG5-11b.   6. up to one broadcast PDSCH is supported in a slot.  7. For any two consecutive slots n and n+1, if there are more than 1 broadcast/multicast/unicast PDSCH in either slot, whether to require the minimum time separation between starting time of any two broadcast/multicast/unicast PDSCHs within the duration of these slots is 4 OFDM symbol for 30kHz and 7 OFDM symbol for 60kHz | 33-1 and/or 33-2, 5-11 and/or 5-11a and/or 5-11b | Yes |  |  | Per FSPC | N/A | N/A |  | Candidate value for component 7: require the minimum time separation time {yes, no} | Optional with capability signalling |
| 33. NR\_MBS | 33-3-3a | FDM-ed Type-1 and Type-2 HARQ-ACK codebooks for multiplexing HARQ-ACK for unicast and HARQ-ACK for multicast | 1. Support of FDM-ed Type-1 HARQ-ACK codebooks for multiplexing HARQ-ACK for unicast and ACK/NACK-based HARQ-ACK for multicast on PUCCH or PUSCH  2. Support of Type-2 HARQ-ACK codebooks for multiplexing HARQ-ACK for unicast and HARQ-ACK for multicast on PUCCH or PUSCH with max number X of G-RNTIs/G-CS-RNTIs | 33-3-2, at least one of {33-2a, 33-4, 33-5-1a, 33-5-1f} | Yes |  |  | Per BC | N/A | N/A |  | Note1: FDM-ed Type-1 HARQ-ACK codebook is generated by concatenating the Type-1 sub-codebook for unicast and the Type-1 sub-codebook for multicast.  Note2: The Type-2 HARQ-ACK codebook is generated by concatenating the Type-2 sub-codebook for unicast and the Type-2 sub-codebook for multicast.  Candidate values of X is {1, 2, 3, 4} with X no larger than max number of G-RNTIs of FG33-2e or G-CS-RNTIs of FG 33-5-1h  Note: the value of X should be common across FG33-2a, 33-3-3a and 33-3-3b if reported | Optional with capability signalling |
| 33. NR\_MBS | 33-3-3b | Mode 2 TDM-ed Type-1 and Type-2 HARQ-ACK codebook for multiplexing HARQ-ACK for unicast and HARQ-ACK for multicast | 1. Support of Mode 2 TDM-ed Type-1 HARQ-ACK codebook for multiplexing HARQ-ACK for unicast and ACK/NACK-based HARQ-ACK for multicast on PUCCH or PUSCH  2. Support of Type-2 HARQ-ACK codebooks for multiplexing HARQ-ACK for unicast and HARQ-ACK for multicast on PUCCH or PUSCH with max number X of G-RNTIs/G-CS-RNTIs | 33-2a or 33-4 or 33-5-1a or 33-5-1f | Yes |  |  | Per BC | N/A | N/A |  | Note1: Mode 2 TDM-ed Type-1 HARQ-ACK codebook is generated based on the union TDRA tables from unicast and multicast and the union of k1 sets from unicast and multicast.  Note2: The Type-2 HARQ-ACK codebook is generated by concatenating the Type-2 sub-codebook for unicast and the Type-2 sub-codebook for multicast.  Candidate values of X is {1, 2, 3, 4} with X no larger than max number of G-RNTIs of FG33-2e or G-CS-RNTIs of FG 33-5-1h  Note: the value of X should be common across FG33-2a, 33-3-3a and 33-3-3b if reported | Optional with capability signalling |
| 33. NR\_MBS | 33-3-4 | Mode 1 for type1 codebook generation | Supports type1-Codebook-Generation-Mode configured as mode 1 | 33-3-3b | Yes |  |  | Per BC | N/A | N/A |  | This FG is for multiplexing HARQ-ACK for unicast and HARQ-ACK for multicast on PUCCH or PUSCH | Optional with capability signalling |
| 33. NR\_MBS | 33-3-5 | Feedback multiplexing for unicast PDSCH and group-common PDSCH for multicast with same priority and different codebook type | Support of multiplexing HARQ-ACK for unicast and for multicast with the same priority and different HARQ-ACK codebook types in a PUCCH or in a PUSCH | 33-2a or 33-4 or 33-5-1a or 33-5-1f | Yes |  |  | Per BC | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-4 | NACK-only based HARQ-ACK feedback for multicast RRC-based enabling/disabling with ACK/NACK transforming | 1. Support NACK-only based HARQ-ACK feedback and support of enabling/disabling NACK-only based HARQ-ACK feedback configured by RRC signalling for dynamic scheduling for multicast, including:  a) A single TB with NACK-only feedback transmitted in PUCCH  b) multiple TB with NACK-only feedback transmitted in PUCCH by transforming into ACK/NACK bits  2. Support of shared PUCCH resource configurations with unicast  3. One or multiple TB with NACK-only feedback transmitted in PUSCH by transforming into ACK/NACK bits  4. One or multiple TB with NACK-only feedback transmitted in PUCCH by transforming into ACK/NACK bits when multiplexing with other UCI | 33-2a | Yes |  |  | Per BC | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-4a | NACK-only based HARQ-ACK feedback for multicast corresponding to a specific sequence or a PUCCH transmission | 1. Support NACK-only based HARQ-ACK feedback for dynamic scheduling for multicast, including:  a) Up to 4 TBs with NACK-only feedback transmitted in PUCCH by select one PUCCH resource.  2. Support of separate PUCCH resource configurations from unicast  3. Single TB with NACK-only feedback transmitted in PUCCH  4. up to 4TBs with NACK-only feedback transmitted in PUSCH by transforming into ACK/NACK bits | 33-4 | Yes |  |  | Per BC | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-4-1 | DCI-based enabling/disabling NACK-only based feedback for dynamic scheduling for multicast | Support of DCI-based enabling/disabling NACK-only based HARQ-ACK feedback configured per G-RNTI by RRC signalling via DCI format 4\_2 | 33-4 and 33-2f | Yes |  |  | Per band | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-5-1 | SPS group-common PDSCH for multicast on PCell | 1. Support one SPS group-common PDSCH configuration for multicast  2. Support {2, 4, 8} times semi-static slot-level repetition for SPS group-common PDSCH  3. Support of group-common PDCCH/PDSCH with CRC scrambled by G-CS-RNTI(s) for multicast  4. Support of DCI format 4\_1 with CRC scrambled with G-CS-RNTI for multicast  5. ACK/NACK-based HARQ-ACK feedback for SPS release associated with G-CS-RNTI | 33-2 | Yes |  |  | Per FS | N/A | N/A |  | one G-CS-RNTI per UE is supported for multicast reception | Optional with capability signalling |
| 33. NR\_MBS | 33-5-1a | Support of ACK/NACK based HARQ-ACK feedback and RRC-based enabling/disabling ACK/NACK-based feedback for SPS group-common PDSCH for multicast | 1. Support of ACK/NACK based HARQ-ACK feedback, and support of enabling/disabling ACK/NACK based HARQ-ACK feedback configured by RRC signalling for SPS group-common PDSCH without PDCCH scheduling, [SPS group-common PDSCH activation]  2. Support of PTM retransmission for SPS multicast associated with G-CS-RNTI  3. Support of Type-1 and Type-2 HARQ-ACK CB for SPS multicast feedback only  4. Support of shared SPS-PUCCH-AN-List configuration from unicast SPS | 33-5-1 | Yes |  |  | Per BC | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-5-1b | DCI-based enabling/disabling ACK/NACK-based feedback for SPS group-common PDSCH for multicast | Support of DCI-based enabling/disabling ACK/NACK based HARQ-ACK feedback configured per G-CS-RNTI for multicast by RRC signaling via DCI format 4\_2 | 33-5-1a, 33-5-1i | Yes |  |  | Per band | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-5-1d | PTP retransmission for SPS group-common PDSCH for multicast | Support of PTP retransmission associated with CS-RNTI for SPS multicast on the cell same as multicast initial transmission | 33-5-1a | Yes |  |  | Per BC | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-5-1e | Dynamic Slot-level repetition for SPS group-common PDSCH for multicast | Support up to X times dynamic slot-level repetition for SPS group-common PDSCH for multicast. | 33-5-1 | Yes |  |  | Per band | N/A | N/A |  | Candidate values for X is: {8, 16}  For TN, the UE shall set the capability value consistently for all FDD-FR1 bands, all TDD-FR1 bands and all TDD-FR2 bands, associated with supported shared and non-shared spectrum respectively. For NTN, UE shall set the capability value consistently for all FDD-FR1 NTN bands. | Optional with capability signalling |
| 33. NR\_MBS | 33-5-1f | NACK-only based HARQ-ACK feedback for multicast RRC-based enabling/disabling NACK-only based feedback for SPS group-common PDSCH for multicast | 1) Support NACK-only based HARQ-ACK feedback, and support of enabling/disabling NACK-only based HARQ-ACK feedback configured by RRC signalling for SPS group-common PDSCH without PDCCH scheduling  a) A single TB with NACK-only feedback transmitted in PUCCH  b) multiple TBs with NACK-only feedback transmitted in PUCCH by transforming into ACK/NACK bits  2) Support of shared PUCCH resource configurations with unicast  3) One or multiple TB with NACK-only feedback transmitted in PUSCH by transforming into ACK/NACK bits  4) One or multiple TB with NACK-only feedback transmitted in PUCCH by transforming into ACK/NACK bits when multiplexing with other UCI | 33-5-1a | Yes |  |  | Per BC | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-5-1g | DCI-based enabling/disabling NACK-only based feedback for SPS group-common PDSCH for multicast | Support of DCI-based enabling/disabling NACK-only based HARQ-ACK feedback configured per G-CS-RNTI for multicast by RRC signaling via DCI format 4\_2 | 33-5-1f, 33-5-1i | Yes |  |  | Per band | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-5-1h | Multiple G-CS-RNTIs for SPS group-common PDSCHs | Max number of G-CS-RNTIs for SPS multicast | 33-5-1 | Yes |  |  | Per band | N/A | N/A |  | For TN, the UE shall set the capability value consistently for all FDD-FR1 bands, all TDD-FR1 bands and all TDD-FR2 bands, associated with supported shared and non-shared spectrum respectively. For NTN, UE shall set the capability value consistently for all FDD-FR1 NTN bands. | Optional with capability signalling |
| 33. NR\_MBS | 33-5-1i | Multicast SPS scheduling with DCI format 4\_2 | 1.Support of DCI format 4\_2 with CRC scrambled with G-CS-RNTI for multicast SPS scheduling  2. Retransmission scheduled by DCI format 4\_2 with CRC scrambled with G-CS-RNTI | 33-5-1 | Yes |  |  | Per band | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-5-1j | NACK-only based HARQ-ACK feedback for multicast corresponding to a specific sequence or a PUCCH transmission for SPS group-commmon PDSCH for multicast | 1. Support NACK-only based HARQ-ACK feedback for SPS PDSCH for multicast, including:  a) Up to 2 TBs with NACK-only feedback transmitted in PUCCH by select one PUCCH resource.  2. Support of separate SPS-PUCCH-AN-List from unicast  3. Single TB with NACK-only feedback transmitted in PUCCH  4. Up to 2TBs with NACK-only feedback transmitted in PUSCH by transforming into ACK/NACK bits | 33-5-1f | Yes |  |  | Per BC | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-5-2 | Multiple SPS group-common PDSCH configuration on PCell | 1. Support up to 8 SPS group-common PDSCH configuration per CFR for multicast  2. Support M>=1 activated SPS group-common PDSCH configurations per CFR for multicast  3. The total number of SPS configurations for both multicast and unicast is no larger than 8 in a BWP of a serving cell, and activated SPS group-common PDSCH configurations is no larger than M.  4. The total number of SPS configurations for both multicast and unicast in a cell group is no larger than 32 | 33-5-1 | Yes |  |  | Per band | N/A | N/A |  | Candidate value set for M is {1, 2, …, 8}  For TN, the UE shall set the capability value consistently for all FDD-FR1 bands, all TDD-FR1 bands and all TDD-FR2 bands, associated with supported shared and non-shared spectrum respectively. For NTN, UE shall set the capability value consistently for all FDD-FR1 NTN bands. | Optional with capability signalling |
| 33. NR\_MBS | 33-5-3 | One SPS group-common PDSCH configuration for multicast for Scell | 1. Support one SPS group-common PDSCH configuration for multicast for Scell.  2. Support {2, 4, 8} times semi-static slot-level repetition for SPS group-common PDSCH for Scell.  3. Support of group-common PDCCH/PDSCH with CRC scrambled by G-CS-RNTI(s) for multicast  4. Support of DCI format 4\_1 with CRC scrambled with G-CS-RNTI for multicast  5. ACK/NACK-based HARQ-ACK feedback for SPS release associated with G-CS-RNTI | 33-5-1, 33-2h | Yes |  |  | Per FSPC | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-5-4 | Up to 8 SPS group-common PDSCH configurations per CFR for multicast for SCell | 1. Support up to 8 SPS group-common PDSCH configuration per CFR for multicast for Scell.  2. Support M>=1 activated SPS group-common PDSCH configurations per CFR for multicast for Scell.  3. The total number of SPS configurations for both multicast and unicast is no larger than 8 in a BWP of a serving cell, and activated SPS group-common PDSCH configurations is no larger than M.  4. The total number of SPS configurations for both multicast and unicast in a cell group is no larger than 32. | 33-5-3 | Yes |  |  | Per FSPC | N/A | N/A |  | Candidate value set for M is {1, 2, …, 8} | Optional with capability signalling |
| 33. NR\_MBS | 33-6-1 | DL priority indication for multicast in DCI | 1. Support of priority indicator field configured in DCI formats 4\_2 with CRC scrambled with G-RNTI for multicast.  2. Supports two HARQ-ACK codebooks with different priorities to be simultaneously constructed different priorities for multicast and multicast at a UE | 33-2a, 33-2f | Yes |  |  | Per band | N/A | N/A |  | For TN, the UE shall set the capability value consistently for all FDD-FR1 bands, all TDD-FR1 bands and all TDD-FR2 bands, associated with supported shared and non-shared spectrum respectively. For NTN, UE shall set the capability value consistently for all FDD-FR1 NTN bands. | Optional with capability signalling |
| 33. NR\_MBS | 33-6-1a | DL priority configuration for SPS multicast | Support of priority indicator field configured in DCI format 4\_2 for multicast HARQ-ACK feedback of SPS multicast | 33-5-1a, 33-5-1i | Yes |  |  | Per band | N/A | N/A |  | For TN, the UE shall set the capability value consistently for all FDD-FR1 bands, all TDD-FR1 bands and all TDD-FR2 bands, associated with supported shared and non-shared spectrum respectively. For NTN, UE shall set the capability value consistently for all FDD-FR1 NTN bands | Optional with capability signalling |
| 33. NR\_MBS | 33-6-2 | Two HARQ-ACK codebooks simultaneously constructed for supporting HARQ-ACK codebooks with different priorities for unicast and multicast at a UE | 1. Supports two HARQ-ACK codebooks with different priorities to be simultaneously constructed different priorities for unicast and multicast at a UE. | 33-6-1 | Yes |  |  | Per band | N/A | N/A |  | For TN, the UE shall set the capability value consistently for all FDD-FR1 bands, all TDD-FR1 bands and all TDD-FR2 bands, associated with supported shared and non-shared spectrum respectively. For NTN, UE shall set the capability value consistently for all FDD-FR1 NTN bands | Optional with capability signalling |
| 33. NR\_MBS | 33-6-3 | More than one PUCCH for HARQ-ACK transmission for multicast or for unicast and multicast within a slot | 1. Supports two non-overlapping slot-based PUCCHs for ACK/NACK based HARQ-ACK feedback for multicast or for unicast and multicast with different priorities in a slot. | 33-6-1, 33-6-2 | Yes |  |  | Per band | N/A | N/A |  | For TN, the UE shall set the capability value consistently for all FDD-FR1 bands, all TDD-FR1 bands and all TDD-FR2 bands, associated with supported shared and non-shared spectrum respectively. For NTN, UE shall set the capability value consistently for all FDD-FR1 NTN bands | Optional with capability signalling |
| 33. NR\_MBS | 33-8-1 | PUCCH resource configuration for multicast feedback for dynamically scheduled multicast | Support of a PUCCH-Config for multicast HARQ-ACK feedback, separate from that of unicast configurations | 33-2a or 33-4 | Yes |  |  | Per BC | N/A | N/A |  | Note: With 33-2a or 33-4 as prerequisite FG, this FG33-8-1 includes the case of ACK/NACK for multicast or NACK-only mode1 for multicast. | Optional with capability signalling |
| 33. NR\_MBS | 33-8-2 | Up to 2 PUCCH resources configuration for multicast feedback for dynamically scheduled multicast | Support of a PUCCH-ConfigurationList for multicast HARQ-ACK feedback, separate from that of unicast configurations | 33-8-1, 33-6-1 | Yes |  |  | Per BC | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-8-3 | PUCCH resource configuration for multicast feedback for SPS GC-PDSCH | Support of a SPS-PUCCH-AN-List for multicast HARQ-ACK feedback of all multicast SPS configuration(s), separate from that of SPS unicast configurations | 33-5-1a | Yes |  |  | Per BC | N/A | N/A |  |  | Optional with capability signalling |
| 33. NR\_MBS | 33-9 | Supporting unicast PDCCH to release SPS group-common PDSCH | Supports unicast PDCCH scrambled with CS-RNTI to release SPS group-common PDSCH | 33-5-1, 12-2 | Yes |  |  | Per band | N/A | N/A |  | For TN, the UE shall set the capability value consistently for all FDD-FR1 bands, all TDD-FR1 bands and all TDD-FR2 bands, associated with supported shared and non-shared spectrum respectively. For NTN, UE shall set the capability value consistently for all FDD-FR1 NTN bands. | Optional with capability signalling |
| 33. NR\_MBS | 33-10 | Support group-common PDSCH RE-level rate matching for multicast | 1) Support of SP ZP-CSI-RS for group-common PDSCH RE-mapping patterns  2) Support of P ZP-CSI-RS for group-common PDSCH RE-mapping patterns  3) Support p-ZP-CSI-RS-ResourceSet configured in PDSCH-Config-Multicast same as or different from the p-ZP-CSI-RS-ResourceSet configured in PDSCH-Config  Note 1: The total number of semi-persistent ZP-CSI-RS-ResourceSet that a UE can be configured with is the same as for unicast in Rel-16  4) Support of AP ZP-CSI-RS for group-common PDSCH RE-mapping patterns | 2-33a, 33-2 | Yes |  |  | Per band | N/A | N/A |  | For TN, the UE shall set the capability value consistently for all FDD-FR1 bands, all TDD-FR1 bands and all TDD-FR2 bands, associated with supported shared and non-shared spectrum respectively. For NTN, UE shall set the capability value consistently for all FDD-FR1 NTN bands. | Optional with capability signalling |