3GPP TSG-RAN WG1 Meeting #114bis R1-23xxxxx

Xiamen, China, 7th – 13th October 2023

**Agenda Item: 9.4.1**

**Title: FL summary #1 on Rel-18 RedCap UE complexity reduction**

**Source: Moderator (Ericsson)**

**Document for: Discussion, Decision**

# 1 Introduction

This feature lead (FL) summary (FLS) concerns the Rel-18 work item (WI) on enhanced support of reduced capability (RedCap) NR devices [1, 2]. The final FLS from the previous RAN1 meeting can be found in [3], and a RAN1 agreement summary is available in [4].

The core part of the WI [1] has the following objective and notes related to further reduced UE complexity:

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| **Complexity/cost reduction**   * Further reduced UE complexity in FR1 [RAN1, RAN2, RAN4]   + UE BB bandwidth reduction     - 5 MHz BB bandwidth only for PDSCH (for both unicast and broadcast) and PUSCH, with 20 MHz RF bandwidth for UL and DL     - The other physical channels and signals are still allowed to use a BWP up to the 20 MHz maximum UE RF+BB bandwidth.   + UE peak data rate reduction     - Relaxation of the constraint (*vLayers*·*Qm*·*f* ≥ 4) for peak data rate reduction     - The relaxed constraint is, e.g., 1 (instead of 4).     - The parameters (*vLayers*, *Qm*, *f*) can be as in Rel-17 RedCap.   + Relation between ‘UE BB bandwidth reduction’ and ‘UE peak data rate reduction’     - A UE can support ‘UE peak data rate reduction’ with or without ‘UE BB bandwidth reduction’.     - The initial access procedure for ‘UE peak data rate reduction’ without ‘UE BB bandwidth reduction’ is the same as for ‘UE peak data rate reduction’ with ‘UE BB bandwidth reduction’.   + The peak rate target is 10 Mbps regardless of what optional features the UE may support.   + Support additional separate early indication(s) [RAN1, RAN2]   + Both 15 kHz SCS and 30 kHz SCS are supported.   + Aim to define at most one Rel-18 RedCap UE type for further UE complexity reduction.   + The existing UE capability framework is used, and changes to capability signalling are specified only if necessary. By default, all UE capabilities applicable to a Rel-17 RedCap UE are applicable unless otherwise specified.   Notes:   * The work defined as part of this WI is not to overlap with LPWA use cases. * Coexistence with non-RedCap UEs and Rel-17 RedCap UEs should be ensured. * This WI considers all applicable duplex modes unless otherwise specified. |

This document summarizes contributions [5] – [28] submitted to agenda item 9.4.1, contribution [29] submitted to agenda item 5, and the following email discussion:

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| [114bis-R18-RedCap] Email discussion on eRedCap – Johan (Ericsson)   * To be used for sharing updates on online/offline schedule, details on what is to be discussed in online/offline sessions, Tdoc number of the moderator summary for online session, etc. |

Issues in this document are tagged and color coded with High Priority, Medium Priority, and Low Priority, and the issues that are in the focus of the initial discussion round are furthermore tagged FL1.

Follow the naming convention in this example:

* *eRedCapFLS1-v000.docx*
* *eRedCapFLS1-v001-CompanyA.docx*
* *eRedCapFLS1-v002-CompanyA-CompanyB.docx*
* *eRedCapFLS1-v003-CompanyB-CompanyC.docx*

If needed, you may “lock” a discussion document for 30 minutes by creating a checkout file, as in this example:

* Assume CompanyC wants to update *eRedCapFLS1-v002-CompanyA-CompanyB.docx*.
* CompanyC uploads an empty file named *eRedCapFLS1-v003-CompanyB-CompanyC.checkout.*
* CompanyC checks that no one else has created a checkout file simultaneously, and if there is a collision, CompanyC tries to coordinate with the company who made the other checkout (see, e.g., contact list below).
* CompanyC then has 30 minutes to upload *eRedCapFLS1-v003-CompanyB-CompanyC.docx.*
* If no update is uploaded in 30 minutes, other companies can ignore the checkout file.
* Note that the file timestamps on the server are in UTC time.

In file names, please use the hyphen character (not the underline character) and include ‘v’ in front of the version number, as in the examples above and in line with the general recommendation (see slide 11 in [R1-2308803](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_114b/Docs/R1-2308803.zip)), otherwise the sorting of the files will be messed up (which can only be fixed by the RAN1 secretary).

To avoid excessive email load on the RAN1 email reflector, please note that there is NO need to send an info email to the reflector just to inform that you have uploaded a new version of this document. Companies are invited to enter the contact info in the table below.

**FL1 Question 1-1a: Please consider entering contact info below for the points of contact for this email discussion.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Point(s) of contact** | **Email address(es)** |
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# 2 UE BB bandwidth reduction

2.0 Earlier agreements

RAN1 has made the following agreements for UE BB bandwidth reduction [4]:

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| **Initial BWP**  Agreement:  For a cell supporting both Rel-17 and Rel-18 RedCap UEs,   * The Rel-18 RedCap UEs can share the same separate initial DL/UL BWP as the Rel-17 RedCap UEs. * FFS: whether to support an additional separate initial DL/UL BWP specific to Rel-18 RedCap UEs   Conclusion:  There is no consensus to continue discussion on “whether additional separate initial DL/UL BWP specific to Rel-18 RedCap UEs is allowed to be configured by the SIB in the cell”.  **Number of PRBs**  Agreement:  For UE BB bandwidth reduction, for PUSCH, select the following option for the maximum number of PRBs that the UE can transmit per slot or per hop, if applicable:   * Option 3: 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS   For UE BB bandwidth reduction, for PDSCH (for both unicast and broadcast), select the following option for the maximum number of PRBs that the UE can process per slot:   * Option 3: 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS   Note: No intention to change the RAN4 RF specifications about maximum transmission PRB number  **PUSCH bandwidth**  Agreement:  For UE BB bandwidth reduction, a UE is not expected to receive an UL grant in a DCI with a PUSCH resource allocation spanning a bandwidth of more than ~5 MHz per slot or per hop, if applicable.  Agreement:  For UE BB bandwidth reduction, a UE is not expected to be configured with a CG grant with a PUSCH resource allocation spanning a bandwidth of more than ~5 MHz per slot or per hop, if applicable.  Agreement:  For UE BB complexity reduction, a UE is not expected to receive an UL grant in a RAR or in a DCI scrambled with TC-RNTI with a Msg3 PUSCH resource allocation spanning a bandwidth of more than ~5 MHz per slot or per hop, if applicable.  Agreement:  For UE BB complexity reduction, a UE is not expected to perform 2-step RACH with a MsgA PUSCH resource spanning a bandwidth of more than ~5 MHz per slot or per hop, if applicable.  **UE post-FFT buffer size**  Conclusion:  For UE BB complexity reduction, for broadcast and unicast PDSCH, RAN1 does not assume that the UE post-FFT buffer size per slot is smaller than 20 MHz  **Unicast PDSCH bandwidth**  Agreement:   * For UE BB complexity reduction, a UE is able to receive a DL assignment in a DCI with a unicast PDSCH resource allocation spanning a bandwidth of more than ~5 MHz per slot. * The number of PRB scheduled in DCI is not larger than the maximum number of PRB agreed in previous agreement from 110b-e   **SIB1/OSI transmission**  Conclusion:  For UE BB complexity reduction, broadcast of separate SIB1/OSI (PDSCH) to Rel-18 RedCap UEs is not supported.  Agreement:   * For UE BB bandwidth reduction, for SIB1 (PDSCH),   + Allow the scheduling of SIB1 to be larger than 5 MHz (as in legacy operation). The scheduling of SIB1 PDSCH is allowed to be larger than 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS. * For UE BB bandwidth reduction, for broadcast OSI (PDSCH),   + Allow the scheduling of broadcast OSI (PDSCH) to be larger than 5 MHz (as in legacy operation). The scheduling of OSI PDSCH is allowed to be larger than 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS.   **Paging bandwidth**  Agreement:  From RAN1 perspective, for UE BB complexity reduction, for paging channel (PDSCH) to Rel-18 RedCap UEs, allow the scheduling of paging channel to be larger than 5 MHz (as in legacy operation). The scheduling of paging PDSCH is allowed to be larger than 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS.  **Msg2 bandwidth, Msg2-Msg3 timeline, and Msg1 indication**  Agreement:  For UE BB bandwidth reduction, for RAR (PDSCH) to Rel-18 RedCap UEs, the scheduling of RAR PDSCH is allowed to be larger than the maximum number of unicast PRBs that the UE can process per slot.   * When the scheduling of RAR PDSCH is within the maximum number of unicast PRBs that the UE can process per slot, the legacy time between RAR reception and Msg3 transmission (not smaller than NT,1 + NT,2 + 0.5 ms) is applied. * When the scheduling of RAR PDSCH is larger than the maximum number of unicast PRBs that the UE can process per slot,   + The UE receives the RAR and correspondingly transmits Msg3 if the TDRA for Msg3 in UL grant in RAR indicates that the time between RAR reception and Msg3 transmission is NOT smaller than NT,1 + NT,2 + 0.5 + X ms.     - FFS: value(s) of X   + Otherwise, the UE behavior is up to the UE implementation. * Note: it does not mean early indication is needed * Note: it will not be used as example for unicast PDSCH   For the “FFS: value(s) of X”   * X = [0.5/0.25 or 1/0.5 or 2/1] ms for 15/30kHz SCS * Note: Single Value pair for X is to selected for SCSs   Agreement:   * For the “FFS: value(s) of X”,   + X = 1/0.5 ms for 15/30 kHz SCS * Legacy default TDRA table and Δ are reused. * A network-configurable additional separate early indication in Msg1 for Rel-18 eRedCap UEs is supported.   + When Msg1 indication for Rel-18 eRedCap UEs is configured, it is used by Rel-18 eRedCap UEs (with or without UE BB bandwidth reduction). * When Msg1 indication for Rel-18 eRedCap UEs is not configured while Msg1 indication for Rel-17 RedCap UEs is configured, Rel-18 eRedCap UEs shall share the PRACH that is configured for Rel-17 RedCap UEs.   + Note: Rel-18 eRedCap UEs will be differentiated from Rel-17 RedCap UEs based on Msg3 of Rel-18 eRedCap UEs. * Additional early indication in MsgA PRACH is not supported.   Agreement:   * For UE BB bandwidth reduction, the same timeline relaxation as for the Msg2-Msg3 timeline applies at least for the following cases:   + Case 4a: Between reception of RAR PDSCH in which UE does not correctly receive the transport block and upcoming transmission of PRACH   + Case 4b: Between reception of RAR with RAPID which is not associated with the corresponding PRACH transmission and upcoming transmission of PRACH   **Msg4 bandwidth**  Agreement:  Confirm the following working assumption by assuming that Msg3 indication is available:   * For UE BB complexity reduction, a UE is able to receive a Msg4 PDSCH resource allocation spanning a bandwidth of more than ~5 MHz per slot.   + The UE is not required to process a Msg4 PDSCH with a larger number of PRBs than 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS.   Agreement:  Final LS [R1-2304262](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_112b-e/Docs/R1-2304262.zip) is endorsed.  **MsgB bandwidth and 2-step RACH timeline**  Agreement:  For UE BB bandwidth reduction, for 2-step RACH, assuming that MsgA PUSCH indication is transmitted:   * The bandwidth of a MsgB scheduled with MSGB-RNTI should be limited in a similar way as Msg2.   + The same timeline relaxation as for the Msg2-Msg3 timeline (i.e., 1 slot for Msg2 PDSCH larger than 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS) applies at least for the following cases:     - Case 2a: Between reception of fallbackRAR and transmission of Msg3     - Case 2b: Between reception of successRAR and transmission of corresponding HARQ-ACK * The bandwidth of a MsgB scheduled with C-RNTI should be limited in a similar way as Msg4.   Agreement:  For UE BB bandwidth reduction, for 2-step RACH, assuming that MsgA PUSCH indication is transmitted:   * The same timeline relaxation as for the Msg2-Msg3 timeline (i.e., 1 slot for Msg2 PDSCH larger than 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS) applies at least for the following cases:   + Case 2c: Between reception of MsgB PDSCH scheduled by MSGB-RNTI in which UE does not correctly receive the transport block in the corresponding PDSCH within the window and transmission of only PRACH according to Type-1 random access procedure or to transmit both PRACH and PUSCH according to Type-2 random access procedure.   + Case 2d: Between reception of MsgB PDSCH scheduled by MSGB-RNTI with RAPID which is not associated with the corresponding PRACH transmission from the UE and transmission of only PRACH according to Type-1 random access procedure or to transmit both PRACH and PUSCH according to Type-2 random access procedure.   **MBS bandwidth**  Agreement:   * For UE BB bandwidth reduction, the number of PRBs scheduled in DCI can be larger than 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS for:   + Broadcast MBS PDSCH without any PDSCH in next slot   + Broadcast MBS PDSCH without MBS PDSCH repetition   **Simultaneous reception**  Conclusion:  For UE BB complexity reduction, there is no need to relax the requirements on simultaneous reception of two broadcast PDSCH transmissions for SIB1/OSI/paging/RAR.  Conclusion:  For UE BB bandwidth reduction, for autonomous SI acquisition, the following paragraph in TS 38.214 clause 5.1 still applies:   * “The UE is expected to decode a PDSCH scheduled with C-RNTI, MCS-C-RNTI, or CS-RNTI during a process of autonomous SI acquisition.” * FFS: Msg4 PDSCH scheduled by TC-RNTI case   Agreement:   * For UE BB complexity reduction, for RRC\_IDLE and RRC\_INACTIVE, there is no need to relax the requirements on simultaneous reception of two PDSCH transmissions for SIB1 / OSI / paging / RAR / Msg4 scheduled by TC-RNTI for the case when Msg4 PDSCH is not larger than 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS. * Note: This means that the following paragraph in TS 38.214 clause 5.1 still applies for the case when Msg4 PDSCH is not larger than 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS:   + “The UE in RRC\_IDLE and RRC\_INACTIVE modes shall be able to decode two PDSCHs each scheduled with SI-RNTI, P-RNTI, RA-RNTI or TC-RNTI, with the two PDSCHs partially or fully overlapping in time in non-overlapping PRBs.”   Conclusion:  For UE BB bandwidth reduction, for Msg4 PDSCH scheduled by TC-RNTI during a process of autonomous SI acquisition, no specification change.  Agreement:   * For handling of multiple reception in a slot during P-RNTI triggered SI acquisition when the total number of PRBs for the PDSCH scheduled with SI-RNTI and the PDSCH scheduled with C-RNTI, MCS-C-RNTI, or CS-RNTI scheduled in the slot is larger than the maximum number of PRBs that the UE can process per slot, the UE may skip decoding of the scheduled PDSCH with C-RNTI, MCS-C-RNTI, or CS-RNTI.   Agreement:   * For UE BB bandwidth reduction, when PDSCH scheduled with RA-RNTI or MSGB-RNTI is not greater than 25/12 PRBs with 15/30kHz SCS, 38.214 clause 5.1 still applies, i.e.:   + “The UE is not expected to decode a PDSCH scheduled with C-RNTI, MCS-C-RNTI, G-RNTI for multicast or broadcast, MCCH-RNTI, G-CS-RNTI or CS-RNTI if another PDSCH in the same cell scheduled with RA-RNTI or MSGB-RNTI partially or fully overlap in time.”   Agreement:   * For UE BB bandwidth reduction, when PDSCH scheduled with RA-RNTI or MSGB-RNTI is greater than 25/12 PRBs with 15/30kHz SCS, support the following UE behavior:   + UE behavior 2: Relaxed random access processing timeline in connected mode:     - The UE is not expected to decode a PDSCH scheduled with C-RNTI, MCS-C-RNTI, G-RNTI for multicast or broadcast, MCCH-RNTI, G-CS-RNTI or CS-RNTI in the same or next slot if another PDSCH in the same cell is scheduled with RA-RNTI or MSGB-RNTI. |

2.1 Random access timeline

Contribution [7] expresses that the following paragraph in 38.213 [31] clause 17.1A does not consider that in 2-step RACH, higher layers can indicate to the physical layer to transmit both PRACH and PUSCH (not just PRACH).

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| When  - a UE receives a PDSCH scheduled by a DCI format with CRC scrambled by a RA-RNTI or a MsgB-RNTI over a number of PRBs that is larger than 25 PRBs for 15 kHz SCS or larger than 12 PRBs for 30 kHz SCS, and  - the UE does not correctly receive the transport block provided by the PDSCH, or if the higher layers at the UE do not identify a RAPID associated with a corresponding PRACH transmission from the UE  the UE shall be ready to transmit a PRACH no later than msec for 15 kHz SCS, or no later than msec for 30 kHz SCS, after the last symbol of the PDSCH reception, or after the last symbol of the window as described in Clauses 8.2 and 8.2A. |

**FL1 High Priority Question 2.1-1a: Is there a need to update the above 38.213 paragraph to consider that in 2-step RACH, higher layers can indicate to the physical layer to transmit both PRACH and PUSCH (not just PRACH)? Please elaborate in the comment field.**

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| **Company** | **Y/N** | **Comments** |
| QC | No | The paragraph mentioned in [7] seems not the above. The paragraph that [7] targets to modify is the following. But anyway, we don’t need the need to update the below neither.  When  - a UE receives a PDSCH scheduled by a DCI format with CRC scrambled by a RA-RNTI or a MsgB-RNTI over a number of PRBs that is larger than 25 PRBs for 15 kHz SCS or larger than 12 PRBs for 30 kHz SCS, and  - the UE does not correctly receive the transport block provided by the PDSCH, or if the higher layers at the UE do not identify a RAPID associated with a corresponding PRACH transmission from the UE  the UE shall be ready to transmit a PRACH no later than msec for 15 kHz SCS, or no later than msec for 30 kHz SCS, after the last symbol of the PDSCH reception, or after the last symbol of the window as described in Clauses 8.2 and 8.2A. |
| FL |  | Thanks for spotting this. I have updated the text snippet above the question, so that it shows the right paragraph. Sorry for any confusion this might have caused. |
| vivo |  | We think it is beneficial to have such correction. |
| Spreadtrum | Y | Thanks Qualcomm for correcting and thanks FL for updating, the modification (red part) is for PRACH transmission, i.e., the following   |  | | --- | | TS 38.213  17.1A Second procedures for RedCap UE  =================Unchanged parts are omitted=================  When  - a UE receives a PDSCH scheduled by a DCI format with CRC scrambled by a RA-RNTI or a MsgB-RNTI over a number of PRBs that is larger than 25 PRBs for 15 kHz SCS or larger than 12 PRBs for 30 kHz SCS, and  - the UE does not correctly receive the transport block provided by the PDSCH, or if the higher layers at the UE do not identify a RAPID associated with a corresponding PRACH transmission from the UE  For Type-1 random access procedure, the higher layers can indicate to the physical layer to transmit a PRACH. For Type-2 random access procedure, the higher layers can indicate to the physical layer to transmit only PRACH according to Type-1 random access procedure or to transmit both PRACH and PUSCH according to Type-2 random access procedure. If requested by higher layers, t~~T~~he UE shall be ready to transmit a PRACH no later than msec for 15 kHz SCS, or no later than msec for 30 kHz SCS, after the last symbol of the PDSCH reception, or after the last symbol of the window as described in Clauses 8.2 and 8.2A.  =============== Unchanged parts are omitted=================== |   The current spec reads like only PRACH can be transmitted, but for 2-Step RACH, the higher layers can indicate to the physical layer to transmit only PRACH according to Type-1 random access procedure or to transmit both PRACH and PUSCH according to Type-2 random access procedure. Therefore, we add the red part (as above) to make it clear.  We need to notice that in section 8.2(4-step RACH) and 8.2A(2-setp RACH), there are also clarifications(listed below) for RACH or RACH+PUSCH transmission to avoid ambiguity. Therefore, we suggest to align with the descriptions in 8.2 and 8.2A.   |  | | --- | | **38.213**  **8.2 Random access response - Type-1 random access procedure**  “the higher layers can indicate to the physical layer to transmit a PRACH. If requested by higher layers, the UE shall be ready to transmit…”  **8.2A Random access response - Type-2 random access procedure**  “the higher layers can indicate to the physical layer to transmit only PRACH according to Type-1 random access procedure or to transmit both PRACH and PUSCH according to Type-2 random access procedure [11, TS 38.321]. If requested by higher layers, the UE shall be ready to transmit” | |
| Nordic | No | There should not be a need. If PRACH is associated with PUSCH then higher layer instruct UE to send PUSCH after PRACH. |
| OPPO |  | We do not read the text in 8.2a will restrict UE only transmit for 4-step RACH. It is not convinced that the change is necessary. |
| CATT | Y | OK. This follows the spirit of previous agreement. |

Contribution [26] proposes to interpret initial access as random access in RRC\_IDLE, meaning that the random access procedure for UEs supporting FG 48-2 and UEs not supporting FG 48-2 should be the same in RRC\_IDLE but can be different in RRC\_INACTIVE and RRC\_CONNECTED.

**FL1 High Priority Question 2.1-2a: Can the “same initial access procedure” (for UEs supporting FG 48-2 and UEs not supporting FG 48-2) be interpreted as “random access in RRC\_IDLE”? Please elaborate in the comment field.**

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| **Company** | **Y/N** | **Comments** |
| QC | Yes | To facilitate a PR1 UE access NW as smooth as a regular UE, the time relaxation and BB restriction should not be applied to the PR1 UE. Therefore, whenever it is possible, the timeline relaxation and BB restriction should not be applied to PR1 UE.  With the above, we think “same initial access procedure” means “random access in RRC\_IDLE”. |
| Vivo |  | We are not sure about the intention of the question. From our understanding, for random access for eRedCap UE in idle and inactive modes, and for contention based random access for eRedCap UE in connected mode, NW cannot differentiate FG48-1 eRedCap and FG48-2 eRedCap UEs, so the same random access procedure should be applied. |
| Spreadtrum |  | In our understanding, we cannot simply say “the random access procedure for UEs supporting FG 48-2 and UEs not supporting FG 48-2 can be different in RRC\_INACTIVE and RRC\_CONNECTED.”   * In connected mode, if CBRA is performed, the gNB still cannot distinguish which type of eRedCap it is (PR1 UE or BW3/PR3 UE), then the random access procedure should also be the same. However, for CFRA, as the gNB knows the type of UE, the time relaxation and BB restriction may not need to be applied to the UEs not supporting FG 48-2. * In idle mode, it is clear that the gNB cannot know UE’s capability. Therefore the random access procedure for UEs supporting FG 48-2 and UEs not supporting FG 48-2 should be the same.   In addition, we doubt the benefits and necessity. For UEs supporting FG 48-2, the relaxed time is actually “optional” at UE side, 1) For Msg3 transmission, the otherwise case is based on UE implementation, the 48-2 UEs can handle larger RAR PDSCH and transmit Msg3 in a short time. 2) For PRACH transmission, the timeline is “no later than”, the 48-2 UE can transmit PRACH as early as possible. 3) For PUCCH HARQ-ACK transmission, the otherwise case is also based on UE implementation, the UE behavior is similar to 1). |
| Nordic | No | Our understanding has been initial access = CBRA random access. i.e. when gNB cannot recognize UE from PRACH, the same initial access applies. |
| OPPO | N | The proposal is trying to optimize FG 48-2 UE in latency. But those benefit is quite small as the whole procedure was considered mainly for FG 48-2.  Differentiate UEs’ behavior in different RRC mode would not help too much for the issue. Would be better to consider if it is CBRA or CFRA.  But it is difficult to re-discuss at this stage. |
| CATT |  | We agree with the analysis of Spreadtrum. Maybe only ‘CFRA in RRC\_CONNECTED’ case can be different. For other cases, including RACH in RRC\_IDLE or CBRA in RRC\_CONNECTED, same random access procedure is needed.  But we do not foresee this makes huge change or brings huge benefit if CFRA of FG48-2 UE does not apply relaxed timeline. |
| FUTUREWEI |  | The question is unclear. Whenever a FG 48-2 UE needs to perform a contention based random access, the network is unable to distinguish a FG 48-2 UE from a FG 48-1 UE until at least after Msg3 is transmitted (for initial access it is after capability exchange). The same random access procedure applies until the networks stops scheduling using the TC-RNTI. |

Contribution [17] expresses that the following paragraphs in 38.213 [31] clause 17.1A do not consider that after initial access, the random access timeline does not need to be relaxed for FG 48-2 UEs.

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| When  - a UE receives a PDSCH scheduled by a DCI format with CRC scrambled by a RA-RNTI or a MsgB-RNTI over a number of PRBs that is larger than 25 PRBs for 15 kHz SCS or larger than 12 PRBs for 30 kHz SCS, and  - the PDSCH includes a RAR message with an RAR UL grant scheduling a Msg3 PUSCH transmission from the UE, as described in Clauses 8.2 and 8.2A  the UE transmits the Msg3 PUSCH if a time between the last symbol of a PDSCH reception conveying the RAR message and the first symbol of the Msg3 PUSCH transmission is not smaller than msec for 15 kHz SCS or msec for 30 kHz SCS where and are defined in clause 8.3; otherwise, the UE behaviour is based on UE implementation.  When  - a UE receives a PDSCH scheduled by a DCI format with CRC scrambled by a RA-RNTI or a MsgB-RNTI over a number of PRBs that is larger than 25 PRBs for 15 kHz SCS or larger than 12 PRBs for 30 kHz SCS, and  - the UE does not correctly receive the transport block provided by the PDSCH, or if the higher layers at the UE do not identify a RAPID associated with a corresponding PRACH transmission from the UE  the UE shall be ready to transmit a PRACH no later than msec for 15 kHz SCS, or no later than msec for 30 kHz SCS, after the last symbol of the PDSCH reception, or after the last symbol of the window as described in Clauses 8.2 and 8.2A.  When  - a UE receives a PDSCH scheduled by a DCI format with CRC scrambled by MsgB-RNTI over a number of PRBs that is larger than 25 PRBs for 15 kHz SCS or larger than 12 PRBs for 30 kHz SCS, and  - the PDSCH includes a RAR message that is for successRAR for the UE as described in Clause 8.2A  the UE transmits a PUCCH with HARQ-ACK information if a time between the last symbol of the PDSCH reception conveying the RAR message and the first symbol of the PUCCH transmission is not smaller than msec for 15 kHz SCS or msec for 30 kHz SCS; otherwise, the UE behaviour is based on UE implementation. |

**FL1 High Priority Question 2.1-3a: Is there a need to update the above 38.213 paragraphs to consider that after initial access, the random access timeline does not need to be relaxed for FG 48-2 UEs? Please elaborate in the comment field.**

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| **Company** | **Y/N** | **Comments** |
| QC | Yes | Similar answer as the one for previous question:  We agree that after initial access (i.e., RRC connected or inactive states), the random access timeline does not need to be relaxed for FG 48-2 UEs. |
| vivo | Yes for CFRA  No for CBRA | For contention based random access for eRedCap UE in connected mode, NW cannot differentiate FG48-1 eRedCap and FG48-2 eRedCap UEs, so the same random access procedure should be applied. |
| Spreadtrum |  | Similar views as our comments for Question 2.1-2a. We are not sure about the benefits and necessity.  In addition, Our understanding for the original version is that these time relaxations are for both idle and connected mode. The TP proposed in [17] reads like for connected mode only, it makes the timeline relaxations for idle mode unclear. |
| Nordic | No | But we fine to clarify that RAR to MSG3 relaxation is applicable to CBRA RA |
| CATT |  | Same view as previous comment. Maybe Y for CFRA. But we do not foresee this makes huge change or brings huge benefit even if CFRA of FG48-2 UE does not apply relaxed timeline. |
| FUTUREWEI |  | Our reply in FL proposal 2.1-2a is applicable. |

2.2 Msg3/MsgA PUSCH bandwidth

TS 38.213 [31] clause 17.1A specifies the following regarding the PUSCH bandwidth for eRedCap UEs:

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| A UE that has not indicated FG 48-2 does not expect to transmit a PUSCH over a bandwidth that is larger than 25 PRBs for 15 kHz SCS, or larger than 12 PRBs for 30 kHz SCS, per hop in a slot.  […]  A UE that indicated FG 48-2 does not expect to transmit a PUSCH over a bandwidth that is larger than 25 PRBs for 15 kHz SCS, or larger than 12 PRBs for 30 kHz SCS, per hop in a slot, where the PUSCH is scheduled by RAR UL grant or by a DCI scrambled by a TC-RNTI, or is configured for a Type-2 random access procedure. |

Several contributions discuss the latter of the two above paragraphs, i.e., the paragraph about Msg3/MsgA PUSCH.

* Contributions [5, 8, 13, 23, 28] propose to remove “that indicated FG 48-2” in the paragraph to ensure the same initial access procedure for all eRedCap UEs.
* Contribution [16], on the other hand, proposes to replace “that indicated FG 48-2” with “that has not indicated FG 48-2”.
* Contribution [17] proposes to add “during CBRA” in the end of the paragraph, so that the bandwidth is only restricted for the CBRA case (not the CFRA case) for UEs supporting FG 48-2.
* Contribution [21] proposes to remove both paragraphs and rely on the eRedCap UE definition in TS 38.306.
* Contributions [6, 19] propose to keep the current wording of the paragraph.

**FL1 High Priority Question 2.2-1a: For the above 38.213 paragraph, companies are invited to indicate which (if any) of the following proposals that they prefer. Please elaborate in the comment field.**

* **Proposal 1: Remove “that indicated FG 48-2”.**
* **Proposal 2: Replace “that indicated FG 48-2” with “that has not indicated FG 48-2”.**
* **Proposal 3: Add “during CBRA” in the end of the paragraph.**
* **Proposal 4: Remove both paragraphs and rely on the eRedCap UE definition in TS 38.306.**
* **Proposal 5: No change.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Proposal(s)** | **Comments** |
| QC |  | We support proposal 4. Or we can take a softened version of proposal 4, which is removing the second paragraph: “A UE that indicated FG 48-2 does not expect to transmit a PUSCH over a bandwidth that is larger than 25 PRBs for 15 kHz SCS, or larger than 12 PRBs for 30 kHz SCS, per hop in a slot, where the PUSCH is scheduled by RAR UL grant or by a DCI scrambled by a TC-RNTI, or is configured for a Type-2 random access procedure.”  If we are not mistaken, there was no RAN1 agreement to support the second paragraph, which was suggested by a company during CR review phase and there was no consensus to add this paragraph as it is.  From technical point of view, this paragraph does not make much sense. A UE indicated FG 48-2 (which means the UE is in connect or inactive state) does not need BB bandwidth restriction to do either CFRA or CBRA RACH.  The argument from proponents of adding this paragraph is a vague note in a RAN-P agreement. The note said same **initial access procedure** of PR1 and PR3 UEs are the same. Our understanding of the note is just about same RACH procedure. It does enforce same timeline relaxation and same BB bandwidth restriction in initial access. Plus, our understanding about the note is only regarding RRC\_IDLE.  By the way, we are also fine with option 2. |
| vivo | Proposal 1 | Following are the reasons for removing the unnecessary sentence of “that indicated FG 48-2”   1. Same initial access procedure as for FG48-1 eRedCap UE should be applied for FG48-2 eRedCap UEs in RRC\_idle/inactive modes (in addition, same contention based random access should also be applied for FG48-2 eRedCap UEs in RRC\_connected mode since NW cannot differentiate the two eRedCap UEs). With “that indicated FG48-2”, it only means the same CBRA is only for FG48-2 eRedCap UEs in RRC\_connected mode. 2. Removing “that indicated FG 48-2” to apply the text for both FG48-1 and FG48-2 eRedCap UEs is clearer and straightforward.  * We understand the text of “A UE that has not indicated FG 48-2 does not expect to transmit a PUSCH over a bandwidth that is larger than 25 PRBs for 15 kHz SCS, or larger than 12 PRBs for 30 kHz SCS, per hop in a slot.” in the first paragraph is for the FG 48-1 eRedCap UEs, and “a PUSCH” in the text covers all kinds of PUSCH. However, in specification, the description for unicast PUSCH and the Msg.3 PUSCH initial/re-transmission is usually separated since they have different procedures and UE behaviors.   About Proposal 3, we do not think we need to add “during CBRA” in the end of the paragraph since Msg.3 is only applicable for CBRS. For CFRA, there is no Msg.3. |
| Spreadtrum | Proposal 1 | Similar views as [5, 8, 13, 23, 28], to ensure the same initial access procedure for all eRedCap UEs.  We can also accept Proposal 4. |
| Nordic |  | We support P1 and P3 |
| OPPO |  | The second sentence is very confusion and would have no base from any agreements. We though that restriction (even with the cited first sentence may be duplicated), can only be applied for 48-2. Although 48-1 and 48-2 share same procedure, it didn’t say same restriction.  Having it has no means for simplification, 48-1 and 48-2 implemented differently.  We can also consider the Option 4. And the 38.306 will describe the UE capabilities. |
| CATT | Proposal 1 [+ 3 if **Question 2.1-3** agrees CFRA] | This issue is coupled with Question 2.1-1~3.  Proposal 1 is our preference.  If we agree that in **Question 2.1-3,** CFRA of FG 48-2 UE does not apply relaxed timeline, we should additionally add ‘for CBRA’ as suggested by proposal 3. |
| FUTUREWEI | Proposal 5 | The clause is directed towards a FG 48-2 UE when the RACH does not indicate that a FG 48-2 is transmitting. The clause simplifies the standards specification in that there is no distinction for the size of Msg3 |

Contributions [10, 22] propose to specify UE behavior for cases when the UE is configured or scheduled with a Msg3/MsgA PUSCH bandwidth that is larger than it can transmit (when no Msg1 early indication is configured), whereas contributions [24, 25] express that there is no need to do so.

**FL1 Low Priority Question 2.2-2a: Should the UE behavior be specified for cases when the UE is configured or scheduled with a Msg3/MsgA PUSCH bandwidth that is larger than it can transmit? Please elaborate in the comment field.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| QC | No |  |
| vivo | No |  |
| Spreadtrum | No |  |
| Nordic | No | we do not need to specify error cases |
| OPPO | No | Those cases are unexpected as the specification current reads. |
| CATT | N | It should already be covered by the following paragraph, which means this is an error case and UE behavior is unspecified.   |  | | --- | | A UE that has not indicated FG 48-2 does not expect to transmit a PUSCH over a bandwidth that is larger than 25 PRBs for 15 kHz SCS, or larger than 12 PRBs for 30 kHz SCS, per hop in a slot. | |

2.3 Msg4 PDSCH bandwidth

RAN1 sent the following LS to RAN2 in [29]:

|  |  |
| --- | --- |
| 1 Overall description  RAN1 discussed Msg4 PDSCH transmission to Rel-18 eRedCap UEs and made the following agreement:   |  | | --- | | Agreement  Confirm the following working assumption by assuming that Msg3 indication is available  Working Assumption   * For UE BB complexity reduction, a UE is able to receive a Msg4 PDSCH resource allocation spanning a bandwidth of more than ~5 MHz per slot.   + The UE is not required to process a Msg4 PDSCH with a larger number of PRBs than 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS. |   RAN1 would like to inform RAN2 about the following case, to consider, if needed, the UE behavior in the RAN2 specifications, and ask RAN2 for feedback if any:   * For UE BB complexity reduction, the case when the UE detects a DCI scheduling a Msg4 PDSCH transmission with a larger bandwidth than it can receive or process   The case was also discussed in RAN1 in Question 2.7-2b of summary [R1-2303936](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_112b-e/Docs/R1-2303936.zip).  2 Actions  **To RAN2:**  **ACTION:** RAN1 respectfully requests RAN2 to take the above into account in their future work and to provide feedback to RAN1 if any. |

RAN1 has received the following LS reply from RAN2 in [30]:

|  |
| --- |
| **1. Overall Description:**  RAN2 would like to thank RAN1 on the LS on Msg4 PDSCH transmission to Rel-18 eRedCap UEs. RAN2 had some discussion on the issue mentioned in the LS, and achieved the following agreement:   * **An eRedCap UE considers the contention resolution not successful and stop the *ra-ContentionResolutionTimer*, when the UE detects a PDCCH transmission addressed to its TEMPORARY\_C-RNTI with a DCI that schedules a Msg4 PDSCH transmission with a larger bandwidth than it can receive or process, i.e. option 1 is adopted.**   **2. Actions:**  **To RAN WG1:**  RAN2 kindly request RAN1 to take the above information into account, and provide feedback, if any. |

Contributions [6, 8, 10, 12, 19, 22] discuss the above reply from RAN2.

* Contribution [6] proposes to clarify in 38.213 [31] clauses 8.4 (‘PDSCH with UE contention resolution identity’) and 17.1A (‘Second procedures for RedCap UE’) that a Rel-18 RedCap UE, for the case when the UE detects a DCI scheduling a Msg4 PDSCH transmission over a number of PRBs that is larger than 25 PRBs for 15 kHz SCS or larger than 12 PRBs for 30 kHz SCS, considers the contention resolution as not successful.
* Contributions [8, 12, 19] propose to specify that the physical layer notifies higher layers when it detects a DCI that schedules a Msg4 PDSCH transmission with a larger bandwidth than the UE can receive or process.

**FL1 High Priority Question 2.3-1a: Is a RAN1 specification change needed for the case discussed in the reply from RAN2? Please elaborate in the comment field.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| QC | No | For the “physical layer notifies higher layers”, this can be done by UE implementation without any specification impact. |
| vivo | Yes | From our understanding, it is beneficial to define the signaling for the cross-layer interaction since MAC layer cannot aware of the FDRA field in the DCI indicating a larger number of PRBs. This is similar to the cross-layer signaling already defined for other functions. |
| Spreadtrum | No | Similar understanding as QC. |
| Nordic | Yes | We support “physical layer notifies higher layers”. |
| OPPO | No | It is not function for RAN1 spec to stop the ra-ContentionResolutionTimer. We can ask RAN2 to support that behavior. Or it can be by implementation. |
| CATT | N | We think it is should be addressed by RAN2 spec (stop the timer). |
| FUTUREWEI | Yes | We can also be fine with letting the spec editor determine whether / how a specification change is needed |

2.4 MBS PDSCH bandwidth

The previous RAN1 meeting discussed the MBS PDSCH bandwidth for the following potential cases [3]:

* Case 1a: Broadcast MBS PDSCH without PDSCH in consecutive slots and without PDSCH repetition
* Case 1b: Broadcast MBS PDSCH with PDSCH in consecutive slots and/or with PDSCH repetition
* Case 2a: Multicast MBS PDSCH without HARQ feedback
  + Case 2a1: Multicast MBS PDSCH without HARQ feedback and without PDSCH repetition
  + Case 2a2: Multicast MBS PDSCH without HARQ feedback but with PDSCH repetition
* Case 2b: Multicast MBS PDSCH with HARQ feedback

The previous RAN1 meeting made the following agreement [4] about the MBS PDSCH bandwidth:

|  |
| --- |
| Agreement:   * For UE BB bandwidth reduction, the number of PRBs scheduled in DCI can be larger than 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS for:   + Broadcast MBS PDSCH without any PDSCH in next slot   + Broadcast MBS PDSCH without MBS PDSCH repetition |

The related paragraph in TS 38.213 [31] clause 17.1A looks like this:

|  |
| --- |
| A UE that has not indicated FG 48-2 is not required to process a PDSCH reception in slot that is scheduled by a DCI format with CRC scrambled by a G-RNTI for broadcast over a number of PRBs that is larger than 25 PRBs for 15 kHz SCS, or larger than 12 PRBs for 30 kHz SCS, when the PDSCH reception is with repetitions or when the UE receives another PDSCH in slot . |

Contributions [5, 6, 8, 9, 10, 12, 13, 14, 16, 17, 18, 19, 22, 24, 25, 27, 28] discuss MBS PDSCH bandwidth.

For broadcast MBS, the following views are expressed in the contributions:

* Contributions [5, 8, 12, 22, 25] propose to consider MCCH-RNTI in the 38.213 paragraph quoted above.
* Contributions [13, 17, 24] express that the MBS PDSCH can be wider than 25/12 PRBs for 15/30 kHz SCS even if MBS PDSCH repetition is used, whereas contributions [20, 25] express that the MBS PDSCH cannot be wider than 25/12 PRBs for 15/30 kHz SCS if MBS PDSCH repetition is used.
* Contributions [8, 17] propose that the PRB restriction should only apply to UEs that do not support FG 48-2.
* Contribution [5] proposes to refer to slots *n-1* and *n* instead of *n* and *n+1* in the 38.213 paragraph quoted above.
* Contribution [10] proposes that the UE decides whether to receive an MBS PDSCH wider than 25/12 PRBs for 15/30 kHz SCS in slot *n* based on the priority of the other PDSCH in slot *n+1*.
* Contribution [14] proposes to clarify the wording from “any PDSCH in next slot” to “any PDSCH reception in next slot”.
* Contribution [27] proposes to clarify that the MBS PDSCH can only be wider than 25/12 PRBs for 15/30 kHz SCS if both conditions are fulfilled (i.e., no PDSCH in next slot, and no MBS PDSCH repetition).

For multicast MBS, the following views are expressed in the contributions:

* Contributions [6, 8, 9, 13, 17, 19, 22, 24, 28] propose that the number of PRBs scheduled in DCI is not larger than 25/15 PRBs for 15/30 kHz SCS, irrespective of whether HARQ feedback is enabled or disabled.
* Contributions [10, 12, 14, 16, 18, 20, 25] propose that the number of PRBs can be larger than 25/15 PRBs for 15/30 kHz SCS when HARQ feedback is disabled, but not when it is enabled.

**FL1 Medium Priority Question 2.4-1a: For broadcast MBS, should MCCH-RNTI be considered in the 38.213 paragraph quoted above? Please elaborate in the comment field.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| QC |  | We don’t have strong view. But we think MCCH-RNTI can be added. |
| vivo | Y | PDSCH scheduled by DCI with CRC scrambled by MCCH-RNTI is also broadcast MBS. |
| Nordic | Y | It should be since broadcast RNTIs are MCCH-RNTI and G-RNTI |
| OPPO | Y | We are OK for that. |
| CATT | Y | This has been discussed in previous CR review phase. |
| FUTUREWEI | Y |  |

**FL1 Medium Priority Question 2.4-2a: For broadcast MBS, which option is preferred?**

* **Option 1: The number of PRBs scheduled in DCI is not larger than 25/15 PRBs for 15/30 kHz SCS when MBS PDSCH repetition is used.**
* **Option 2: The number of PRBs can be larger than 25/15 PRBs for 15/30 kHz SCS when MBS PDSCH repetition is used.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option (1/2)** | **Comments** |
| QC | Option 1 | PR3 UE cannot handle back-to-back PDSCH decoding larger than 25/15 PRBs for 15/30 kHz SCS, just following the logic we used to settle down many similar scenarios in previous meetings. |
| vivo | Option 2 | FG48-1 eRedCap should not impact the broadcast MBS for legacy UEs. We prefer option 2 and for such case, the UE is not required to process the MBS PDSCH repetition in the following slots. |
| Spreadtrum | Option 1 | We don’t think UE has capability to process the case in option2. |
| Nordic | Option 1 | However, if it is clarified that UE may skip every other repetition, we OK as well with Option 2.  Proposal should have, “For BB limited UE”? |
| OPPO | Option 1 |  |
| CATT | Option 2 | When broadcast MBS PDSCH is repeated, the content of MBS PDSCH is the same (though RV can be different). FG 48-1 UE is free to receive only one of the repetitions to decode MBS PDSCH.  The UE is NOT required to receive or process all repetitions (or say, MBS in next/following slot) to decode this MBS PDSCH. |
| FUTUREWEI | Option 1 | Prefer to keep specifications simple |

**FL1 Medium Priority Question 2.4-3a: For broadcast MBS, should the PRB restriction only apply for FG 48-1 UEs that do not support FG 48-2? Please elaborate in the comment field.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| QC | Yes | PR1 UE (with FG 48-2) does not need PRB restriction. |
| Vivo | Yes |  |
| Spreadtrum |  | Logically speaking, the PRB restriction should only apply for FG 48-1 UEs that do not support FG 48-2. However, whether we need spec change to reflect this? |
| Nordic | Yes | R17 MBS applies to connected mode, if not mistaken. |
| OPPO | Yes |  |
| CATT | Y |  |

**FL1 Medium Priority Question 2.4-4a: For broadcast MBS, companies are invited to indicate which (if any) of the following proposals that they think should be prioritized in this meeting.**

* **Proposal 1: Contribution [5] proposes to refer to slots *n-1* and *n* instead of *n* and *n+1* in the 38.213 paragraph quoted above.**
* **Proposal 2: Contribution [10] proposes that the UE decides whether or not to receive a MBS PDSCH wider than 25/12 PRBs for 15/30 kHz SCS in slot *n* based on the priority of the other PDSCH in slot *n+1*.**
* **Proposal 3: Contribution [14] proposes to clarify the wording from “any PDSCH in next slot” to “any PDSCH reception in next slot”.**
* **Proposal 4: Contribution [27] proposes to clarify that the MBS PDSCH can only be wider than 25/12 PRBs for 15/30 kHz SCS if both conditions are fulfilled (i.e., no PDSCH in next slot, and no MBS PDSCH repetition).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Proposal(s)** | **Comments** |
| QC | Proposal 4 | Although we think proposal 4 is aligned with the interpretation of the existing agreement, if companies think there is ambiguity, this should be clarified. |
| Vivo | Proposal 1 | We think proposal 1 can relax the UE complexity since the UE is not required to wait for the look-ahead check. |
| Spreadtrum | Proposal 4 | We think proposal 4 is the correct understanding for the agreements achieved in the last RAN1 meeting. |
| Nordic | P3, P4 |  |
| OPPO | Proposal 4 | We actually try to clarify this in the last meeting. We think the both condition should be applied (i.e., no PDSCH in next slot, and no MBS PDSCH repetition). |
| CATT |  | Maybe OK to proposal 1 if consensus is reached.  For Proposal 4, in our understanding, current wording in 213 already mean this (UE is NOT required…when the PDSCH reception is with repetitions OR when the UE receives another PDSCH in slot ) |
| FUTUREWEI |  | A slight preference to proposal 1 – as its behavior in the current slot is based on the previous slot |

**FL1 Medium Priority Question 2.4-5a: For multicast MBS, which option is preferred?**

* **Option 1: The number of PRBs scheduled in DCI is not larger than 25/15 PRBs for 15/30 kHz SCS, irrespective of whether HARQ feedback is enabled or disabled.**
* **Option 2: The number of PRBs can be larger than 25/15 PRBs for 15/30 kHz SCS when HARQ feedback is disabled, but not when it is enabled.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option (1/2)** | **Comments** |
| QC |  | We disagree with both options. We think RAN1 should follow the existing formulations of different cases for multicast and discuss them case by case.   * Case 2a: Multicast MBS PDSCH without HARQ feedback   + Case 2a1: Multicast MBS PDSCH without HARQ feedback and without PDSCH repetition   + Case 2a2: Multicast MBS PDSCH without HARQ feedback but with PDSCH repetition * Case 2b: Multicast MBS PDSCH with HARQ feedback |
| FL |  | My thinking is that the answers to this question in combination with the answers to Question 2.4-2a (about the broadcast MBS repetition case) will probably give enough guidance when it is time to formulate the initial proposals.  Note that Option 2 in this question does not say that the maximum bandwidth only depends on whether the HARQ feedback is enabled or disabled. |
| vivo | Option 1 | It simplifies a lot and no need to have different handling for different cases given the UE capability is already known by the NW. |
| Spreadtrum | Option 1 | For simplify, we think multicast MBS should be limited within 25/15 PRBs for 15/30 kHz SCS, irrespective of whether HARQ feedback and/or repetition are enabled or disabled. |
| Nordic | Option 1 for all cases | For simplicity. Multicast can be configured separately for R18 RedCap UEs, so there is no need to over-optimize. |
| OPPO | Option2 |  |
| CATT | Option 1 | For MBS’s sake let’s make it simpler. |
| FUTUREWEI | Option 1 | It simplifies the specifications |

2.5 MBS simultaneous reception

Contributions [9, 10, 24, 25] discuss simultaneous reception or prioritization of MBS PDSCH and another PDSCH.

* Contributions [10, 24] note that UE features for FDM (and TDM) between unicast PDSCH and MBS PDSCH are already defined (see table below from TR 38.822 [33]) and that these can be reused for eRedCap.
* Contribution [9] proposes that a UE capable of FDM should be able to receive unicast PDSCH and MBS PDSCH simultaneously if the total bandwidth does not exceed 25/12 PRBs for 15/30 kHz SCS, otherwise the UE prioritizes unicast PDSCH over MBS PDSCH during two slots.
* Contribution [25] proposes that simultaneous reception should be supported conditioned on that the eRedCap UE capabilities are not exceeded. For broadcast, this would mean single-layer transmission with max 64QAM and max 10 Mbps in total. For multicast, it is proposed to introduce additional UE capabilities to indicate whether more than one layer and/or higher modulation order than 64QAM can be supported.

|  |  |  |  |
| --- | --- | --- | --- |
| 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. 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. 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 |

**FL1 Medium Priority Question 2.5-1a: Should the UE receive MBS PDSCH and another PDSCH simultaneously under some circumstances? If the answer is yes, please comment on those circumstances in the comment field. If the answer is no, please comment on how the UE should prioritize between the two PDSCHs.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| QC | Yes | Simultaneous MBS + unicast PDSCH is not much different than simultaneous SIB/paging/RAR + unicast PDSCH. So, on high level, this feature should be supported.  The overall condition to allow simultaneous MBS PDSCH and another PDSCH is that the sum data rate of the FDMed MBS and another PDSCH does not exceed the peak data rate of 10Mbps. For PR1 UE, this sum data rate constraint is sufficient. For PR3 UE, maybe additional BW restriction can be considered.  On low level, there are some minor differences between MBS + unicast PDSCH vs legacy SIB/paging/RAR + unicast PDSCH. The difference is that SIB/paging/RAR is capped with single layer and 64QAM. While, multicast MBS can have >1 layers and >64QAM. Therefore, a dedicated UE capability can be introduced to handle those scenarios of multicast MBS with >1 layers and >64QAM + unicast PDSCH. |
| vivo | Y | If the total number of PRBs for MBS PDSCH and another PDSCH does not exceed the UE processing capability. |
| Spreadtrum | Yes | E.g., the total bandwidth does not exceed 25/12 PRBs for 15/30 kHz SCS |
| Nordic | OK | given condition by SPRD |
| OPPO | Y | If the overlapped part does not exceed 5MHz. |
| CATT | Y | If total bandwidth does not exceed 5 MHz. |

Contribution [10] mentions that according to legacy behavior, the UE may be expected to decode PDSCH scheduled with MCCH-RNTI and PBCH that partially or fully overlap in time.

**FL1 Medium Priority Question 2.5-2a: Should the UE receive MCCH PDSCH and PBCH simultaneously under some circumstances? If the answer is yes, please comment on those circumstances in the comment field. If the answer is no, please comment on how the UE should prioritize between the two transmissions.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| QC | Yes | Given this feature is supported by legacy UE, eRedcap can support this feature, as long as the sum data rate of the FDMed MCCH PDSCH and PBCH does not exceed the peak data rate of 10Mbps. For PR1 UE, this sum data rate constraint is sufficient. For PR3 UE, maybe additional BW restriction can be considered. |
| vivo | Yes | We think may be no restriction/condition is needed for this case. |
| Spreadtrum | Yes | E.g., the total bandwidth does not exceed 25/12 PRBs for 15/30 kHz SCS |
| Nordic | Yes | condition same as SPRD |
| OPPO | Yes | It should satisfy date rate and bandwidth cap. |
| CATT | Y | PBCH will exceed 5 MHz (for 30kHz SCS) itself, but still Yes in our view.  We already have the following conclusion. Broadcast MBS should also be counted.   |  | | --- | | Conclusion:  For UE BB complexity reduction, there is no need to relax the requirements on simultaneous reception of two broadcast PDSCH transmissions for SIB1/OSI/paging/RAR. | |

2.6 MBS UE features

Contribution [24] discusses MBS UE features specific to Rel-18 eRedCap UEs. For example, the following feature groups in TR 38.822 [33] have components associated with decoding in consecutive slots or slot-level repetition, which might not be supported by UEs with UE BB bandwidth reduction.

|  |  |  |  |
| --- | --- | --- | --- |
| 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 |
| 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 |

**FL1 Medium Priority Question 2.6-1a: Is there a need to introduce MBS UE feature groups specific to eRedCap UEs? Please elaborate in the comment field.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| QC | Yes | It is not a good idea to reuse Rel-17 Redcap UE capabilities for Rel-18 eRedcap UE capabilities. This does not have any benefit (except saved a few pages in 38.306) but could create a lot of confusion to implementation. |
| vivo | FFS | We are open to discuss whether to introduce new FG or make some clarifications for existing MBS FGs for Rel-18 eRedCap. |
| Nordic | No | R17 capa can be indicated and R18 eRedCap differences specified |
| CATT | FFS | Let’s conclude issues in Section 2.4 and 2.5 first. |
| FUTUREWEI | FFS | Because there are over 40 FGs for Rel-17 MBS, we should consider if we can reuse the existing feature groups. |

# 3 UE peak data rate reduction

3.0 Earlier agreements

RAN1 has made the following agreements for UE peak data rate reduction [4]:

|  |
| --- |
| Agreement:   * UE peak data rate reduction is supported at least as an add-on to UE BB bandwidth reduction,   + The constraint *vLayers*·*Qm*·*f* ≥ 4 is relaxed to *vLayers*·*Qm*·*f* ≥ X.   + FFS: the value of X * If UE peak data rate reduction is supported as a standalone feature,   + The constraint *vLayers*·*Qm*·*f* ≥ 4 is relaxed to *vLayers*·*Qm*·*f* ≥ Y.   + FFS: the value of Y   + Note: Whether this option is supported will be decided in RAN plenary.   Agreement:   * The minimum DL peak rate target (for FD-FDD) is 10 Mbps based on peak data rate calculation according to 38.306. * The same value for X is used for DL and UL   Agreement:   * For UE peak data rate reduction with UE BB bandwidth reduction,   + The 10-Mbps peak rate target corresponds to a *vLayers*·*Qm*·*f* of 3.2 * For UE peak data rate reduction without UE BB bandwidth reduction,   + The 10-Mbps peak rate target corresponds to a *vLayers*·*Qm*·*f* of 0.75   + This is assuming 20 MHz bandwidth in the 38.306 peak rate expression. * Note: This does not imply that downlink MIMO and 256 QAM are not supported   Agreement:   * The UE needs to signal peak data rate 10-Mbps related parameters corresponding to *vLayers*, *Qm* and *f*.   + No new values for the above parameters will be introduced for Rel-18 eRedCap.   + For FG 48-2, when *vLayers* = 2, the peak rate target corresponds to a *vLayers*·*Qm*·*f* of 0.8 (instead of 0.75).   Conclusion:   * For Rel-18 eRedCap UEs, the following features are still supported as optional features:   + 2 Rx branches with DL MIMO   + DL 256QAM   Agreement:   * Send LS to RAN2 (cc RAN4) to inform about RAN1 agreements on peak rate reduction with 38.306 impact.   Agreement:  Final LS [R1-2308610](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_114/Docs/R1-2308610.zip) is endorsed. |

3.1 Relaxed constraints

Contribution [12] expresses that the current default values of the peak rate related UE capability parameters are not suitable for eRedCap UEs and proposes to follow one of these directions:

* **Direction 1:** Specify that it is mandatory for Rel-18 eRedCap UEs to report UE capability related RRC parameters *scalingFactor*, *supportedModulationOrderDL* and *supportedModulationOrderUL* to the gNB.
* **Direction 2:** Introduce new default values for *scalingFactor*, *supportedModulationOrderDL* and *supportedModulationOrderUL*.

**FL1 High Priority Question 3.1-1a: Is there an issue with the current default values of the peak rate related UE capability parameters that needs to be addressed? Please elaborate in the comment field.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | Maybe | Similar issue is also discussed in section 2 of R1-2309422. Same handling can be adopted. |
| Spreadtrum |  | According to 38.306, the default value for *scalingFactor* is 1. The default values for *supportedModulationOrderDL* and *supportedModulationOrderUL* are 256QAM (i.e., 8) and 64QAM (i.e., 6), respectively. The *vLayers*·*Qm*·*f* calculated by the default values (e.g., 6, 8) cannot align to the value we agreed for R18 eRedCap (e.g., 3.2, 0.75, 0.8).  However, we think this issue can be treated in RAN2. |
| Nordic | Y | Redcap will always have to report values despite there is single value based on number of layer and FG48-1/2 … does not make sense. But RAN2 should make the spec change, we can only ask them to consider. |
| CATT | Y, but | Should be addressed by RAN2. |
| FUTUREWEI |  | Because the product is known for FG 48-1 and 48-2, there are already constraints on the possible values. For FG48-2, the product 0.75 has values of {1, 1, 0.75} for{vlayer, Qm, f}; and the values for the product 0.8 are {2, 1, 0.4}. |

3.2 Combinations with optional features

Contribution [18] expresses that the optional feature DL 256QAM should not apply to UEs support FG 48-2.

**FL1 Low Priority Question 3.2-1a: Should support of DL 256QAM be precluded for UEs supporting FG 48-2?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| QC | No |  |
| Spreadtrum | No |  |
| Nordic | Somewhat support | If gNB does not limit BW, for PR1 UE then will not be able to schedule 256QAM anyway 😊. If gNB limits BW, then it is de-facto becomes PR1+PR3 feature. There seem to be good technical bases for the proposal. |
| CATT | No |  |
| FUTUREWEI | No |  |

# 4 Detailed spec text proposals

The submitted contributions bring up some specification text aspects not covered elsewhere in this document.

**FL1 Low Priority Question 4-1a: Should the following proposal be treated in this meeting?**

* **Contribution [16] proposes to move the specification from 38.213 to 38.214 about that the maximum 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS for PUSCH and PDSCH allocated to an eRedCap UE should not be exceeded.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Nordic |  | We somewhat agree, but as for now, all (e)RedCap has been in one section in 213. Perhaps better to keep it that way. |
| OPPO | Y | The key problem is that the 38.213 is the UE procedure for control. And the current text is about the data channel:  Especially for PUSCH  “A UE that has indicated FG 48-1 does not expect to transmit a PUSCH over a bandwidth that is larger than 25 PRBs for 15 kHz SCS, or larger than 12 PRBs for 30 kHz SCS, per hop in a slot.”  It mentions no control. Put them into 38.214 would be consistent with other content.  I trace back the introduction CRs and document. It seems they initially try to copy the “R1-2308228 RAN1 agreements for Rel-18 NR RedCap”, compiled at the last day of #114. Each agreements are marked with recommend spec.. Please note the spec. number are recommendation not agreements themselves. |
|  |  |  |

**FL1 Low Priority Question 4-2a: Should the following proposal be treated in this meeting?**

* **Contribution [22] provides a 38.213 TP for clarification of the random access timeline relaxation’s (i.e., X’s) dependency on the SCS.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Nordic | N | UL and DL SCS should be always same for RedCap UE |
|  |  |  |
|  |  |  |

# 5 Other aspects

The submitted contributions bring up the following other aspects which are not covered in any other section in this FLS.

**Common PUCCH**

* Consider enhancements of user multiplexing capacity for common PUCCH [15].
* Do not think PUCCH will become the bottleneck during random access [19].
* Impacts would need to be carefully considered before deciding to do this [25].

**FDRA optimization**

* Discuss whether/how to use potential spare bits in FDRA field in RAR UL grant [9].
* For unicast, the FDRA indications and RBG sizes can be based on 5-MHz sub-bands [11].

**Frequency hopping**

* Support frequency hopping at least for unicast PUSCH [11].
* Study how to improve Msg3 frequency hopping range [18].

**HD-FDD scheduling**

* HD-FDD UE is capable of processing one additional unicast DCI scheduling PUSCH, as in TDD [28].

Contribution [28] proposes to allocate time for discussion of these aspects, whereas contribution [13] argues that none of these aspects are essential for Rel-18 RedCap.

**FL1 Low Priority Question 5-1a: Is there a need to treat any of the issues listed above in this meeting?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Nordic | Y | At least for topics that were never discussed in offline. |
|  |  |  |
|  |  |  |

# References

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| --- | --- | --- | --- |
| [1] | [RP-232671](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_101/Docs/RP-232671.zip) | Revised WID on Enhanced support of reduced capability NR devices | Ericsson |
| [2] | [R1-2300177](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300177.zip) | WI work plan for Rel-18 RedCap | Rapporteur (Ericsson) |
| [3] | [R1-2308227](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_114/Docs/R1-2308227.zip) | FL summary #4 on Rel-18 RedCap UE complexity reduction | Moderator (Ericsson) |
| [4] | [R1-2308228](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_114/Docs/R1-2308228.zip) | RAN1 agreements for Rel-18 NR RedCap | Rapporteur (Ericsson) |
| [5] | [R1-2308896](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2308896.zip) | Maintenance of Rel-18 RedCap | Huawei, HiSilicon |
| [6] | [R1-2308939](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2308939.zip) | Discussion on R18 RedCap | FUTUREWEI |
| [7] | [R1-2308989](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2308989.zip) | Maintenance on enhanced support of RedCap devices | Spreadtrum Communications |
| [8] | [R1-2309078](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2309078.zip) | Remaining issues on further UE complexity reduction | Vivo |
| [9] | [R1-2309177](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2309177.zip) | Discussion on further UE complexity reduction | ZTE, Sanechips |
| [10] | [R1-2309301](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2309301.zip) | Remaining issues of further UE complexity reduction for eRedCap | LG Electronics |
| [11] | [R1-2309379](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2309379.zip) | Remaining issues on further UE complexity reduction for eRedCap | Samsung |
| [12] | [R1-2309460](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2309460.zip) | Discussion on further complexity reduction for eRedCap UEs | Xiaomi |
| [13] | [R1-2309530](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2309530.zip) | Remaining issues of Rel-18 RedCap | CATT |
| [14] | [R1-2309541](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2309541.zip) | MBS for eRedCap | Panasonic |
| [15] | [R1-2309551](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2309551.zip) | Remaining issues on UE complexity reduction for eRedCap UEs | China Telecom |
| [16] | [R1-2309611](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2309611.zip) | Further consideration on reduced UE complexity | OPPO |
| [17] | [R1-2309675](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2309675.zip) | Maintenance on further complexity reduction for eRedCap | CMCC |
| [18] | [R1-2309719](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2309719.zip) | Remaining issues on UE complexity reduction | Transsion Holdings |
| [19] | [R1-2309724](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2309724.zip) | Remaining Issues for eRedCap | Nokia, Nokia Shanghai Bell |
| [20] | [R1-2309837](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2309837.zip) | Further RedCap UE complexity reduction | Apple |
| [21] | [R1-2309877](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2309877.zip) | Maintenance on Rel-18 RedCap UE | NEC |
| [22] | [R1-2309883](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2309883.zip) | Remaining issues on UE complexity reduction | Sharp |
| [23] | [R1-2309974](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2309974.zip) | Maintenance on eRedCap complexity reduction | MediaTek Inc. |
| [24] | [R1-2310037](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2310037.zip) | Maintenance on further UE complexity reduction for eRedCap | NTT DOCOMO, INC. |
| [25] | [R1-2310145](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2310145.zip) | Remaining issues for UE complexity reduction for eRedCap | Qualcomm Incorporated |
| [26] | [R1-2310226](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2310226.zip) | Clarification of random access for Rel-18 eRedCap | Ericsson |
| [27] | [R1-2310230](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2310230.zip) | Remaining issues on eRedCap UE complexity reduction | Sony |
| [28] | [R1-2310240](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2310240.zip) | On further complexity reduction of NR UE | Nordic Semiconductor ASA |
| [29] | [R1-2304262](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_112b-e/Docs/R1-2304262.zip) | LS on Msg4 PDSCH transmission to Rel-18 eRedCap UEs | RAN1, Ericsson |
| [30] | [R1-2308830](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114b/Docs/R1-2308830.zip) | Reply LS to RAN1 on Msg4 PDSCH transmission to Rel-18 eRedCap UEs | RAN2, Vivo |
| [31] | [TS 38.213 V18.0.0](https://www.3gpp.org/ftp/Specs/archive/38_series/38.213/38213-i00.zip) | NR; Physical layer procedures for control (Release 18) | 3GPP |
| [32] | [TS 38.214 V18.0.0](https://www.3gpp.org/ftp/Specs/archive/38_series/38.214/38214-i00.zip) | NR; Physical layer procedures for data (Release 18) | 3GPP |
| [33] | [TR 38.822 V17.1.0](https://www.3gpp.org/ftp/Specs/archive/38_series/38.822/38822-h10.zip) | NR; User Equipment (UE) feature list (Release 17) | 3GPP |