3GPP TSG-RAN WG1 Meeting #112 R1-23xxxxx

Athens, Greece, 27th February – 3rd March 2023

**Agenda Item: 9.6.1**

**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]. FLSs from the previous RAN1 meeting can be found in [3, 4, 5, 6], and a RAN1 agreement summary is available in [7].

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.     - Support additional separate early indication(s) [RAN1, RAN2]   + 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.   + 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.   Check in RAN#99 regarding:   * Whether UE peak data rate reduction for UE is limited only with UE BB bandwidth reduction or standalone |

This document summarizes contributions [9] – [35] submitted to agenda item 9.6.1 and the following email discussion:

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| [112-R18-RedCap] 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 – Johan (Ericsson) |

The issues in this document are tagged and color coded with High Priority or Medium Priority. The issues that are in the focus of this round of the email discussion 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 12 in [R1-2300003](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300003.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)** |
| vivo | Lihui Wang | wanglihui@vivo.com |
| CATT | Yongqiang Fei | feiyongqiang@catt.cn |
| Intel | Yingyang Li | yingyang.li@intel.com |

# 2 UE BB bandwidth reduction

2.0 Earlier agreements

RAN1 has made the following agreements for UE BB bandwidth reduction [7]:

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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   **Number of PRBs**  Agreement:  For UE BB bandwidth reduction, for PUSCH, down-select between the following options 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 * Option 4: 25 PRBs for 15 kHz SCS and 11 PRBs for 30 kHz SCS   For UE BB bandwidth reduction, for PDSCH (for both unicast and broadcast), down-select between the following options 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 * Option 4: 25 PRBs for 15 kHz SCS and 11 PRBs for 30 kHz SCS   Same option will be selected for both PDSCH and PUSCH.  **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.  **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**  Agreement:  For UE BB bandwidth reduction, for SIB1 (PDSCH),   * Allow the scheduling of SIB1 to be larger than 5 MHz (as in legacy operation)   Agreement:  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)     Conclusion:  For UE BB complexity reduction, broadcast of separate SIB1/OSI (PDSCH) to Rel-18 RedCap UEs is not supported.  **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).  **RAR bandwidth**  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 |

2.1 Max number of PRBs

RAN1 has made the following agreement regarding the maximum number of PRBs for PUSCH and PDSCH [7]:

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| Agreement:  For UE BB bandwidth reduction, for PUSCH, down-select between the following options 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 * Option 4: 25 PRBs for 15 kHz SCS and 11 PRBs for 30 kHz SCS   For UE BB bandwidth reduction, for PDSCH (for both unicast and broadcast), down-select between the following options 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 * Option 4: 25 PRBs for 15 kHz SCS and 11 PRBs for 30 kHz SCS   Same option will be selected for both PDSCH and PUSCH. |

Contributions [9, 10, 12, 13, 15, 16, 17, 19, 30, 33, 34, 35] express support for Option 3, whereas contributions [11, 18, 20, 21, 23, 25, 26, 27, 28, 31, 32] express support for Option 4. Furthermore, contribution [11] expresses that an LS needs to be sent to RAN4 to check the feasibility before some other option than Option 4 is selected.

Contribution [28] proposes to express the scheduling restriction for unicast in RB symbol units instead of PRBs.

**FL1 High Priority Question 2.1-1a: Companies are invited to indicate their preference between Options 3 and 4 on a scale from 3.0 to 4.0, where e.g.:**

* **The value 3.0 indicates a strong preference for Option 3.**
* **Values between 3.0 and 3.5 indicate a preference for Option 3 (but can live with Option 4).**
* **The value 3.5 indicates no preference between the two options.**
* **Values between 3.5 and 4.0 indicate a preference for Option 4 (but can live with Option 3).**
* **The value 4.0 indicates a strong preference for Option 4.**

**As usual, other comments are also welcome in the comment field.**

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| **Company** | **Value between 3.0 and 4.0** | **Comments** |
| vivo | 3.2 |  |
| Sharp | 3.9 |  |
| CATT | 3.1 |  |
| Intel | 3.0 | We have one general comments. The possible product can only takes   * 3, which is 1 layer, Qm=4 and scaling factor 0.75 * 3.2, which is 1 layer, Qm=4 and scaling factor 0.8   Do we need to consider a value other than 3 or 3.2? |

2.2 Random access timeline

RAN1 has made the following agreement regarding the RAR bandwidth and Msg3 timeline [7]:

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| 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 |

In the above agreement, the value(s) for X is FFS. The contributions discuss the following main approaches:

* **Approach 1: X is dependent on the RAR PDSCH bandwidth:** Several contributions [9, 11, 13, 14, 15, 23, 25, 33, 35] express that the value of X can depend on whether the RAR PDSCH bandwidth. For example, it could be up to 3 slots (i.e., up to 3 ms for 15 kHz SCS, and up to 1.5 ms for 30 kHz SCS) depending on whether the bandwidth is in the range 5-10 MHz, 10-15 MHz, or 15-20 MHz.
* **Approach 2: X is not dependent on the RAR PDSCH bandwidth:** Several contributions [10, 11, 12, 15, 17, 19, 25, 32, 33] express that the value of X could be fixed if it is sufficiently large in all cases. For example, it can be fixed to 1 slot or 1 ms. One contribution [32] proposes an as low value as a half slot (i.e., 0.5 ms for 15 kHz SCS, and 0.25 ms for 30 kHz SCS).
* **Approach 3: X may be zero even when RAR PDSCH is wider than 5 MHz:** One contribution [28] expresses that X can be 0 not only for the case when the RAR PDSCH bandwidth is less than 5 MHz but also when the RAR PDSCH TBS is smaller than, e.g., 1280 bits. A few other contributions [18, 33] also express that X=0 can be considered.
* **Approach 4: X is configurable by the network:** One contribution [26] proposes that X should be configurable by the network, e.g., in SIB1.
* **Approach 5: X is up to the UE implementation:** Another contribution [29] argues that the UE behavior can be up to the UE implementation and that there is no need to define X.

Contributions [14, 15] indicate that the usable number of row indices in the default PUSCH TDRA table (38.214 Table 6.1.2.1.1-2) may become too low. Contribution [14] proposes to consider larger *Δ* value(s) in case the RAR PDSCH bandwidth is larger than 5 MHz, and contribution [15] proposes to support PUSCH TDRA configuration specific to Rel-18 eRedCap UEs.

Contributions [24, 25, 32] express that the timeline for several other cases may also need to be similarly relaxed, e.g., between Msg4 and its associated HARQ feedback, between RAR and potential Msg1 retransmission, etc.

The following five questions invite companies to express preferences and comments on the five approaches listed above.

**FL1 High Priority Question 2.2-1a: Please indicate your preferences and comments on this approach:**

* **Approach 1: X is dependent on the RAR PDSCH bandwidth:** Several contributions [9, 11, 13, 14, 15, 23, 25, 33, 35] express that the value of X can depend on whether the RAR PDSCH bandwidth. For example, it could be up to 3 slots (i.e., up to 3 ms for 15 kHz SCS, and up to 1.5 ms for 30 kHz SCS) depending on whether the bandwidth is in the range 5-10 MHz, 10-15 MHz, or 15-20 MHz.

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| **Company** | **Y/N** | **Comments** |
| vivo | Y | Different UE implementations should be accommodated for. So, we think the maximum value of X can be 3 slots. |
| CATT |  | We think the processing time does not grow linearly with the RAR PDSCH bandwidth. Hence it is difficult to set up a clear relationship between RAR BW and X. A single value of X is still preferred. |
| Intel | N | BW dependent X is NOT our preference. We prefer a single value for simplicity. For example, considering the worst case, X can be fixed to 3 ms for 15 kHz SCS and 1.5 ms for 30 kHz SCS. |

**FL1 High Priority Question 2.2-2a: Please indicate your preferences and comments on this approach:**

* **Approach 2: X is not dependent on the RAR PDSCH bandwidth:** Several contributions [10, 11, 12, 15, 17, 19, 25, 32, 33] express that the value of X could be fixed if it is sufficiently large in all cases. For example, it can be fixed to 1 slot or 1 ms. One contribution [32] proposes an as low value as a half slot (i.e., 0.5 ms for 15 kHz SCS, and 0.25 ms for 30 kHz SCS).

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| **Company** | **Y/N** | **Comments** |
| vivo |  | Depends on eRedCap UE implementation whether faster process not dependent on the RAR PDSCH bandwidth is possible. |
| Sharp |  | 2nd preference |
| CATT | Y | A single value of X is simpler and considerable. We also support X=1(ms). |
| Intel | Y | Considering the worst case, X can be fixed to 3 ms for 15 kHz SCS and 1.5 ms for 30 kHz SCS. |

**FL1 High Priority Question 2.2-3a: Please indicate your preferences and comments on this approach:**

* **Approach 3: X may be zero even when RAR PDSCH is wider than 5 MHz:** One contribution [28] expresses that X can be 0 not only for the case when the RAR PDSCH bandwidth is less than 5 MHz but also when the RAR PDSCH TBS is smaller than, e.g., 1280 bits. A few other contributions [18, 33] also express that X=0 can be considered.

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| **Company** | **Y/N** | **Comments** |
| vivo |  | Depends on eRedCap UE implementation and whether we would like to introduce other restriction like smaller TBS. |
| Sharp | Y | Since we have agreed that some common PDSCHs (e.g. SIB1, paging PDSCH) can have bandwidths greater than 5MHz without additional handling, and that the maximum data rate of RAR PDSCH is always below 10Mbps, we believe that the processing time for RAR PDSCH does not need to be relaxed in all cases, which is beneficial for some cases, e.g.no need for additional early indication in msg1. |
| CATT | Y | We agree that the current timeline is a loose one. We are supportive if X can be 0. |
| Intel | N | We prefer to not discuss again X=0 which essentially means no processing time relaxation, which conflicts with the assumption that UE is only capable of processing up to 25 or 11(12) PRBs in a slot. |

**FL1 High Priority Question 2.2-4a: Please indicate your preferences and comments on this approach:**

* **Approach 4: X is configurable by the network:** One contribution [26] proposes that X should be configurable by the network, e.g., in SIB1.

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| **Company** | **Y/N** | **Comments** |
| vivo |  | We can discuss whether it is beneficial to have X configurable after the decision made that there are more than one values for X. |
| CATT |  | We think X is more related to UE processing capability but not NW configuration. |
| Intel | N | X is related to UE capability and is used before gNB knows the UE capability. As a result, even if X can be configured from multiple values, a UE has to implement based on the smallest X, otherwise the UE may fail in RAR PDSCH reception when a smaller X is configured. Therefore, X should be predefined. |

**FL1 High Priority Question 2.2-5a: Please indicate your preferences and comments on this approach:**

* **Approach 5: X is up to the UE implementation:** Another contribution [29] argues that the UE behavior can be up to the UE implementation and that there is no need to define X.

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| **Company** | **Y/N** | **Comments** |
| vivo | N | If X is not defined, NW will have no reference on the timing setting when scheduling RAR with BW larger than 5MHz for eRedCap UEs. |
| CATT |  | We think Approach 5 is the same as X=0 (i.e. no additional X is defined) |
| Intel | N | Without an assumption on value X, gNB cannot know which row in the TDRA table is applicable for msg3 scheduling. In extreme case, if X is longer than 3 slots, there maybe no schedulable row in the TDRA table for msg3 which results in broken of the RACH procedure. |

2.3 Separate early indication

RAN#98e added an objective to support additional separate early indication(s) for UE BB bandwidth reduction [1]:

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| * 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.     - Support additional separate early indication(s) [RAN1, RAN2] |

In the above objective, it is still open whether to support additional separate early indication(s) in Msg1 only, or in Msg3 only, or in both Msg1 and Msg3, when it comes to 4-step RACH. The contributions express the following preferences:

* **At least Msg1:** Contributions [21, 25, 31] propose to support additional separate early indication in Msg1.
* **Both Msg1 and Msg3:** Contributions [9, 15, 16, 19, 23, 24, 27, 29, 32, 33] propose to support additional separate early indications in both Msg1 and Msg3. Contributions [19, 21] propose to clarify that it should also be possible to configure a Msg1 indication that is shared between Rel-17 RedCap and Rel-18 eRedCap UEs.
* **At least Msg3:** Contribution [22] proposes to support additional separate early indication at least in Msg3, possibly also in Msg1 (configurable).
* **Only Msg3, not Msg1:** Contributions [12, 13, 14, 26, 34, 35] propose to support additional separate early indication in Msg3 only.
* **Msg1 and/or Msg3:** Contributions [10, 11] express that additional separate early indications can be delivered by Msg1 and/or Msg3. Contribution [11] expresses that the down-selection should be made by RAN1, whereas contributions [10, 17, 20] express that it is up to RAN2.

Several contributions also mention that beside the 4-step RACH case (with Msg1 and Msg3), the 2-step RACH case (with MsgA PRACH and MsgA PUSCH) should be addressed.

Based on the above considerations, perhaps the following proposal can be considered.

**FL1 High Priority Proposal 2.3-1a: From RAN1 perspective, support additional separate early indications in:**

* **For 4-step RACH: Msg1 and Msg3**
* **For 2-step RACH: MsgA PRACH and MsgA PUSCH**

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| **Company** | **Y/N** | **Comments** |
| vivo | N | We should first discuss the necessity for MSG1 as additional separate early indication. |
| Sharp |  | For 4-step RA, it is OK. For 2-step RA, it can wait for the discussion of 2.8 |
| CATT |  | From RAN1’s view we do not find strong motivation to support early indication in Msg1. But RAN2 starts discussion on R18 RedCap early indication in this meeting. This can be left to RAN2, just as RACH partitioning in R17. If RAN1 finds reasons why early indication in Msg1/MsgA PRACH is necessary/essential, RAN1 can help RAN2 facilitate the discussion. |
| Intel | Y | Since the timeline on processing time relaxation for RAR PDSCH was agreed, it is advantageable to let gNB knows the UE type before transmission of RAR PDSCH. EI by msg1 is useful reference for msg3 scheduling too. |

2.4 Separate initial BWP

RAN1 has made the following agreement regarding separate initial BWP(s) [7]:

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| 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 |

The above agreement has an FFS regarding whether to support an additional separate initial DL/UL BWP specific to Rel-18 RedCap UEs. The last related FL proposal discussed in the previous RAN1 meeting was the following one [6]:

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| RAN1#111 Medium Priority Proposal 2.4-3b:   * For a cell supporting Rel-17 and/or Rel-18 RedCap UEs,   + Up to one separate (RedCap-specific) initial DL/UL BWP can be configured ~~for the following cases:~~     1. ~~Only Rel-17 RedCap UEs~~     2. ~~Only Rel-18 RedCap UEs~~     3. ~~Both Rel-17 and Rel-18 RedCap UEs~~   + ~~Note: Here, “Rel-18 RedCap UE” means a UE implementing the UE complexity reductions introduced by the Rel-18 RedCap WI.~~ |

Contribution [33] proposes to support an additional separate initial BWP specific to Rel-18 eRedCap UEs, whereas contributions [9, 10, 11, 12, 15, 16, 17, 19, 20, 21, 26, 32, 34, 35] express that they see no need for it. However, contribution [11] proposes to add an FFS for the dedicated (NPN) network case.

Contributions [14, 33] propose to support both the case that the (single) separate initial BWP is configured only for Rel-18 eRedCap UEs and the case that the separate initial BWP is configured for both Rel-17 RedCap UEs and Rel-18 eRedCap UEs, where the detailed signaling solution would be up to RAN2. Contribution [15] also expresses that this approach should be considered.

Based on the above considerations, perhaps the following proposal can be considered.

**FL1 High Priority Proposal 2.4-1a:**

* **No additional separate initial DL/UL BWP specific to Rel-18 RedCap UEs is introduced.**
  + **Whether it should be supported that Rel-18 RedCap UEs use a separate initial DL/UL BWP while Rel-17 RedCap UEs and non-RedCap UEs use the normal initial DL/UL BWP is up to RAN2.**

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| **Company** | **Y/N** | **Comments** |
| vivo | Y with comments | We support the intention with the proposal. But still it is not clear theNo additional separate initial DL/UL BWP is from UE perspective or “cell” perspective. To correctly reflect the intention, we suggest following modification”   * **No additional separate initial DL/UL BWP specific to Rel-18 RedCap UEs is ~~introduced~~ configured by the same SIB1 message.** |
| Sharp | Y |  |
| CATT | Y, but | 1) This should be cell perspective. Fine with vivo’s update if it helps clarifying.  2) The sub-bullet seems wired. We do not see the benefit to make such division. |
| Intel | Y | Fine to leave the issue to RAN2 |

2.5 Simultaneous reception

For simultaneous reception of multiple broadcast channels, 38.214 clause 5.1 specifies the following:

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| 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. |

For simultaneous reception of a unicast channel and a broadcast channel, 38.214 clause 5.1 specifies the following:

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| On a frequency range 1 cell, the UE shall be able to decode a PDSCH scheduled with C-RNTI, MCS-C-RNTI, or CS-RNTI and, during a process of P-RNTI triggered SI acquisition, another PDSCH scheduled with SI-RNTI that partially or fully overlap in time in non-overlapping PRBs, unless the PDSCH scheduled with C-RNTI, MCS-C-RNTI, or CS-RNTI requires Capability 2 processing time according to clause 5.3 in which case the UE may skip decoding of the scheduled PDSCH with C-RNTI, MCS-C-RNTI, or CS-RNTI.  On a frequency range 2 cell, the UE is not expected to decode a PDSCH scheduled with C-RNTI, MCS-C-RNTI, or CS-RNTI if in the same cell, during a process of P-RNTI triggered SI acquisition, another PDSCH scheduled with SI-RNTI partially or fully overlap in time.  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. |

Contributions [14, 23] propose that an eRedCap UE should not be required to support reception of any two PDSCHs multiplexed in an FDM manner in a slot if the two PDSCHs span more than 5 MHz.

Contributions [15, 19] propose to reuse the existing FR2 specification, meaning that the UE should not be expected to simultaneously receive a unicast PDSCH and a broadcast PDSCH, whereas contribution [32] expresses that there is no need to define any additional UE behavior at all.

Contributions [15, 18, 26, 32] propose that simultaneous reception of two broadcast PDSCHs can follow the same principle as the reception of a single broadcast PDSCH, i.e., the UE may process them over multiple slots if their combined bandwidth exceeds 5 MHz.

Contributions [9, 13, 14, 33] propose to discuss whether there is a need to specify a PDSCH processing order when two PDSCHs are scheduled in the same slot.

Furthermore, contribution [26] proposes to support simultaneous reception of PDSCH and SSB/PDCCH/CSI-RS as well as simultaneous transmission of PUSCH and PUCCH.

**FL1 High Priority Question 2.5-1a: Is there a need to relax the mentioned requirements on simultaneous reception of two broadcast PDSCHs? Please elaborate in the comment field.**

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| **Company** | **Y/N** | **Comments** |
| vivo | Y | At least for PDSCH scheduled with RA-RNTI and TC-RNTI. |
| Sharp | N | UEs can handle broadcast PDSCH with no requirement of strict timing constraints in multiple slots, and processing priority can be up to UE implementations. |
| CATT | N | For broadcast channels that do not require feedback, we think no need to relax. |
| Intel | Y | A UE anyway only has the capability to decode up to 25 or 11 (12) PRBs in a slot. If the total number of two PDSCHs are more than 25 or 11 (12), the UE cannot decode both PDSCHs |

**FL1 High Priority Question 2.5-2a: Is there a need to relax the mentioned requirements on simultaneous reception of one unicast PDSCH and one broadcast PDSCH? Please elaborate in the comment field.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | Y | For unicast PDSCH, it may be scheduled in consecutive slots, for such case, eRedCap UE may not be able to process the broadcast PDSCH. |
| Sharp | N | UEs can handle broadcast PDSCH with no requirement of strict timing constraints in multiple slots, and processing priority can be up to UE implementations. |
| CATT |  | We agree that the decoding of broadcast PDSCH may be delayed, but since the broadcast PDSCH does not require feedback, is there any spec impact? |
| Intel | Y | A UE anyway only has the capability to decode up to 25 or 11 (12) PRBs in a slot. If the total number of two PDSCHs are more than 25 or 11 (12), the UE cannot decode both PDSCHs |

2.6 Paging PDSCH bandwidth

RAN1 has made the following agreement regarding the PDSCH bandwidth for paging [7]:

|  |
| --- |
| 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). |

Contribution [19] proposes to clarify that this means that the number of scheduled PRBs in the PDSCH resource allocation for paging can be larger than the maximum number of PRBs supported for unicast PDSCH.

**FL1 Medium Priority Proposal 2.6-1a: Update the agreement for PDSCH paging with the clarification as follows:**

* **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). It means the scheduling of paging PDSCH is allowed to be larger than the maximum number of unicast PRBs that the UE can process per slot.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | Y |  |
| Sharp | Y |  |
| CATT | Y |  |
| Intel |  | We agree with the intention of the proposal. However, it may not necessary require an update. If the updated proposal is necessary, we prefer to clarify it for all kinds of broadcast PDSCH. |

2.7 Msg4 PDSCH bandwidth

RAN1 has made the following agreement regarding the unicast PDSCH bandwidth [7]:

|  |
| --- |
| 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 |

Contribution [29] proposes to restrict the PDSCH bandwidth for Msg4 in a similar way as in the above agreement.

**FL1 Medium Priority Question 2.7-1a: Should the Msg4 PDSCH bandwidth be limited in the same way as in the above agreement for unicast PDSCH transmissions?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | Y |  |
| Sharp | Y |  |
| CATT | Y | Seems natural since Msg4 is UE-specific. |
| Intel | Y | In our understanding, msg4 is already covered by the existing agreement |

2.8 MsgA PUSCH bandwidth

RAN1 has made the following agreement regarding the PUSCH bandwidth [7]:

|  |
| --- |
| 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. |

Contributions [16, 18] discuss the MsgA PUSCH bandwidth (in case of 2-step RACH). Contribution [16] proposes to restrict the PUSCH bandwidth for MsgA in a similar way as in the above agreement, and to consider different options for coexistence with MsgA PUSCH transmissions from legacy UEs.

**FL1 Medium Priority Question 2.8-1a: Should the MsgA PUSCH bandwidth be limited in the same way as in the above agreements for other PUSCH transmissions?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | Y |  |
| Sharp | N | It can depend on network configuration. if a separate MsgA resource is configured for eRedCap, the MsgA PUSCH bandwidth should be limited within 5MHz, otherwise, eRedCap UE can share the msgA resource with RedCap UE. |
| CATT | Y |  |
| Intel | Y | We prefer unified design for all PUSCHs |

# 3 UE peak data rate reduction

3.0 Earlier agreements

RAN1 has made the following agreements for UE peak data rate reduction [7]:

|  |
| --- |
| 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 |

3.1 Target data rate

RAN#98e made the following decision [36], as noted by several contributions [17, 22, 26, 27, 34].

|  |
| --- |
| Issue 4: Minimum target (downlink) peak data rate:  Proposal: Keep the minimum target peak rate as 10Mbps  […]  Conclusion: proposals for issue 3 and issue 4 are agreed |

Based on the above decision, the following proposal can be considered.

**FL1 High Priority Proposal 3.1-1a: Revise the earlier agreement by removing the square brackets like this:**

* **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**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | Y |  |
| Sharp | Y |  |
| CATT | Y |  |
| Intel | Y |  |

3.2 Add-on feature

For the case when UE peak data rate reduction is an add-on to UE BB bandwidth reduction, most contributions [9, 10, 11, 13, 14, 15, 17, 19, 22, 23, 25, 26, 28, 30, 31, 32, 33, 34] propose to adopt a value of X in the range between 3.0 and 3.4. A couple of contributions [12, 16] propose to adopt a lower value (1 and 2, respectively). One contribution [27] notes that 3.2 would reach the target peak rate but anyway proposes to adopt value 4, i.e., no relaxation.

Contributions [15, 17] express that this decision should be made after the down-selection between Options 3 and 4 in Section 2.1.

Furthermore, contributions [26, 28] propose to consider introducing a new peak rate scaling factor (*f*) value.

**FL1 High Priority Question 3.2-1a: What value of X should be adopted (assuming Option 3 or 4 in Section 2.1)?**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Value of X assuming Option 3** | **Value of X assuming Option 4** | **Comments** |
| vivo | 3 or 3.2 | 3 or 3.4 |  |
| CATT | 3 or 3.2 | 3 or 3.2 |  |
| Intel | 3 | 3 | From the following calculation, the proper X for 10Mbps peak rate is always different for SCS 15kHz or 30kHz. The necessary X for 15kHz is always lower (either 11 or 12 PRBs). Therefore, we believe the proper way is to allow a lower X value based on SCS 15kHz. In such case, peak data rate is 10Mbps for 15kHz and is lower than 10Mbps for 30kHz. Then, it is up to UE capability to support higher X for larger data rate for SCS 30kHz.   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **SCS (kHz)** |  | **Peak DL rate** | | **Peak UL rate** | | | **If X=4** | **X for 10Mbps** | **If X=4** | **X for 10Mbps** | | 15 | 25 | 13.4 | 2.99 | 14.3 | 2.8 | | 30 | 11 | 11.8 | 3.39 | 12.6 | 3.17 | | 30 | 12 | 12.8 | 3.13 | 13.7 | 2.92 | |

3.3 Standalone feature

For the case when UE peak data rate reduction is a standalone feature, if supported, some contributions [14, 17, 30] propose to adopt Y=1. A couple of contributions [22, 31] propose to adopt a lower value (0.7 and 0.75, respectively).

Whether to support UE peak data rate reduction as a standalone feature is expected to be discussed in RAN#99 [1].

**FL1 Medium Priority Question 3.3-1a: If UE peak data rate reduction would be supported as a standalone feature, what value of Y should be adopted?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Value of Y** | **Comments** |
| vivo | 1 |  |
| CATT | 1 |  |
| Intel |  | We prefer to wait for guideline from RAN plenary |

# 4 Other aspects

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

**Cell barring**

* Introduce a new cell barring indication and an IFRI field in SIB1 [16].
* The final decision on whether to introduce additional cell access/barring indication is up to RAN2 [17].

**Feature group / UE type / capability reporting**

* Define new and/or reuse existing RedCap-related UE feature groups [11].
* The new UE type is defined by its support of UE BB bandwidth reduction [16].
* The new UE type is defined by its support of the two UE complexity reduction features [26].

**FDRA optimization**

* There is no need to consider potential optimization of FDRA indications [17, 18, 28, 35].
* Consider potential optimizations of FDRA indication for PUSCH but not for PDSCH [13].
* Consider potential optimizations of FDRA indications in case of large RBG size [25].
* Discuss whether/how to use potential spare bits in FDRA field in RAR UL grant [25].
* For unicast, the FDRA indications and RBG sizes can be based on 5-MHz sub-bands [29].

**Other functionality**

* Consider enhancements of user multiplexing capacity for common PUCCH [25, 33].
* Restrict the SRS bandwidth to 5 MHz, like the other UL bandwidths [28].
* Support PRS- and SRS-based positioning methods [11].
* Support operation in dedicated spectrum <5 MHz at least optionally [11].
* Confirm whether and how to support MBS, SUL, V2X, and NR-U [11].

To be able to focus on more pressing issues, the above aspects could be down-prioritized in this meeting.

**FL1 Medium Priority Question 4-1a: Is there a need to treat any of the issues listed above in this meeting?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | N |  |
| CATT | N | We are open to comeback once most essential issues are addressed. |
|  |  |  |

# References

|  |  |  |  |
| --- | --- | --- | --- |
| [1] | [RP-223544](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_98e/Docs/RP-223544.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] | [R1-2212533](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_111/Docs/R1-2212533.zip) | FL summary #1 on Rel-18 RedCap UE complexity reduction | Moderator (Ericsson) |
| [4] | [R1-2212534](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_111/Docs/R1-2212534.zip) | FL summary #2 on Rel-18 RedCap UE complexity reduction | Moderator (Ericsson) |
| [5] | [R1-2212535](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_111/Docs/R1-2212535.zip) | FL summary #3 on Rel-18 RedCap UE complexity reduction | Moderator (Ericsson) |
| [6] | [R1-2212536](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_111/Docs/R1-2212536.zip) | FL summary #4 on Rel-18 RedCap UE complexity reduction | Moderator (Ericsson) |
| [7] | [R1-2212982](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_111/Docs/R1-2212982.zip) | RAN1 agreements for Rel-18 NR RedCap | Rapporteur (Ericsson) |
| [8] | [TR 38.865 V18.0.0](https://ftp.3gpp.org/Specs/archive/38_series/38.865/38865-i00.zip) | Study on further NR RedCap UE complexity reduction (Release 18) | RAN1 |
| [9] | [R1-2300058](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300058.zip) | Discussion on R18 RedCap complexity techniques | FUTUREWEI |
| [10] | [R1-2300114](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300114.zip) | Discussion on potential solutions to further reduce UE complexity | Huawei, HiSilicon |
| [11] | [R1-2300229](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300229.zip) | Discussion on enhanced support of RedCap devices | Spreadtrum Communications, New H3C |
| [12] | [R1-2300272](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300272.zip) | Further consideration on reduced UE complexity | OPPO |
| [13] | [R1-2300371](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300371.zip) | Discussion on further UE complexity reduction | ZTE, Sanechips |
| [14] | [R1-2300464](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300464.zip) | Discussion on further UE complexity reduction | Vivo |
| [15] | [R1-2300500](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300500.zip) | Further RedCap UE complexity reduction | Ericsson |
| [16] | [R1-2300586](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300586.zip) | Discussion on further complexity reduction for eRedCap UEs | Xiaomi |
| [17] | [R1-2300691](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300691.zip) | Discussion on further complexity reduction for Rel-18 RedCap UE | CATT |
| [18] | [R1-2300794](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300794.zip) | Discussion on UE complexity reduction | Sharp |
| [19] | [R1-2300852](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300852.zip) | UE complexity reduction for eRedCap | Panasonic |
| [20] | [R1-2300855](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300855.zip) | Discussion on Rel-18 RedCap UE | NEC |
| [21] | [R1-2300858](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300858.zip) | UE complexity reduction | Lenovo |
| [22] | [R1-2300884](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300884.zip) | UE complexity reduction for eRedCap | Sony |
| [23] | [R1-2300959](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300959.zip) | Discussion on complexity reduction for eRedCap UE | Intel Corporation |
| [24] | [R1-2301078](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301078.zip) | Discussion on UE complexity reduction | DENSO CORPORATION |
| [25] | [R1-2301106](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301106.zip) | Discussion on further UE complexity reduction for eRedCap | LG Electronics |
| [26] | [R1-2301149](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301149.zip) | RedCap UE Complexity Reduction | Nokia, Nokia Shanghai Bell |
| [27] | [R1-2301188](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301188.zip) | Considerations for further UE complexity reduction | Sierra Wireless. S.A. |
| [28] | [R1-2301874](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301874.zip) | On further complexity reduction of NR UE (revision of [R1-2301193](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301193.zip)) | Nordic Semiconductor ASA |
| [29] | [R1-2301275](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301275.zip) | Further UE complexity reduction for eRedCap | Samsung |
| [30] | [R1-2301309](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301309.zip) | Discussion on UE complexity reduction | Transsion Holdings |
| [31] | [R1-2301357](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301357.zip) | Further RedCap UE Complexity Reduction | Apple |
| [32] | [R1-2301424](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301424.zip) | UE complexity reduction for eRedCap | Qualcomm Incorporated |
| [33] | [R1-2301504](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301504.zip) | Discussion on further UE complexity reduction for eRedCap | NTT DOCOMO, INC. |
| [34] | [R1-2301772](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301772.zip) | Discussion on further reduced UE complexity (revision of [R1-2301013](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301013.zip)) | CMCC |
| [35] | [R1-2301783](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301783.zip) | On eRedCap UE complexity reduction (revision of [R1-2301608](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301608.zip)) | MediaTek Inc. |
| [36] | [RP-230052](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_99/Docs/RP-230052.zip) | Revised draft report of electronic meeting RAN #98e | ETSI MCC |