3GPP TSG-RAN WG1 Meeting #110bis-e Draft R1-2210249

e-Meeting, 10th – 19th October 2022

**Agenda Item: 9.6.1**

**Title: FL summary #2 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]. This Rel-18 RedCap WI was preceded by Rel-17 RedCap WI [3, 4], a Rel-18 study item (SI) on further UE complexity reduction [5] and a RAN plenary discussion on the Rel-18 RedCap WI scope [6].

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.
	+ 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#98-e regarding:* Whether UE peak data rate reduction for UE is limited only with UE BB bandwidth reduction or standalone
* Whether or not/how a separate early indication can be supported
* Other restrictions of the WI (e.g., connectivity restrictions, band, etc.)
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This document summarizes contributions [7] – [35] submitted to agenda item 9.6.1 and the following email discussion:

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| [110bis-e-R18-RedCap-01] Email discussion on further UE complexity reduction by October 19 – Johan (Ericsson)* Check points: October 14, October 19
 |

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 discussion are furthermore tagged FL1. The initial FLS is available in [36].

Follow the naming convention in this example:

* *eRedCapFLS2-v000.docx*
* *eRedCapFLS2-v001-CompanyA.docx*
* *eRedCapFLS2-v002-CompanyA-CompanyB.docx*
* *eRedCapFLS2-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 *eRedCapFLS2-v002-CompanyA-CompanyB.docx*.
* CompanyC uploads an empty file named *eRedCapFLS2-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 *eRedCapFLS2-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 16 in [R1-2208323](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208323.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)** |
| Huawei, HiSilicon | Frank Long | frank.longyi@huawei.com |
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| Qualcomm | Yongjun Kwak | yongkwak@qti.qualcomm.com |

# 2 UE BB bandwidth reduction

**Maximum number of PRBs**

Several contributions [11, 15, 16, 28, 29] propose that the maximum number of contiguous PRBs for PDSCH and PUSCH is 25 PRBs for 15 kHz SCS and 11 PRBs for 30 kHz SCS. A few contributions [8, 13] propose 25 PRBs and 12 PRBs, respectively. One contribution [14] proposes 27 PRBs and 13 PRBs, respectively. One contribution [35] proposes 28 PRBs and 14 PRBs, respectively. A couple of contributions [18, 20] propose to send an LS to RAN4 to ask about the maximum number of PRBs.

For information,

* For 15 kHz SCS, the occupied bandwidth for {25, 26, 27, 28, 29} PRBs is {4.50, 4.68, 4.86, 5.04, 5.22} MHz
* For 30 kHz SCS, the occupied bandwidth for {11, 12, 13, 14, 15} PRBs is {3.96, 4.32, 4.68, 5.04, 5.40} MHz

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

**FL1 High Priority Proposal 2-1a: For UE BB bandwidth reduction, for PDSCH (for both unicast and broadcast) and PUSCH, down-select between the following options for the maximum number of contiguous PRBs:**

* **Option 1: 28 PRBs for 15 kHz SCS and 14 PRBs for 30 kHz SCS**
* **Option 2: 27 PRBs for 15 kHz SCS and 13 PRBs for 30 kHz SCS**
* **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**

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| **Company** | **Y/N** | **Preferred option(s),if any** | **Comments** |
| Huawei, HiSilicon |  | Option 4 | Option 4 is in line with the current PRB number specified in RAN4 for 5MHz channel bandwidth. |
| Nordic  | Y | Option 3 |  |
| MediaTek | N |  | In general, we are OK with PUSCH to be confined with 5MHz physically contiguous resource blocks. However, for PDSCH in the main bullet, we have concerns and cannot agree to it before **we clarify further whether/how Rel-18 eRedCap can *indeed* reduce its post-FFT buffer size for *most* of the OFDM symbols in a slot.** 1. As agreed in RAN#97e and promised by RAN chair, PR3 can be revisited. We are not fine with confining PDSCH resource allocation to 5MHz (i.e. BW3). PR3 vs BW3 discussion should be revisited for both broadcast and unicast PDSCHs.
2. For broadcast PDSCHs, based on the coverage evaluation results in TR 38.865, it is more reasonable to allow gNB to transmit them with resource allocation bandwidth more than 5MHz.
3. For unicast PDSCHs, we currently still believe that post-FFT buffer in eRedCap will likely support up to 20MHz for almost every symbol, if not all, in a slot (taking lower PDCCH decoding capability, support for CSI-RS up to 20MHz, and LTE-NR dual-mode support into account). Hence, we prefer to understand companies’ assumption UE’s post-FFT buffer size first.

With the above, we would like to revise the FL’s proposal as follows: **Revised Proposal: For UE BB bandwidth reduction, for ~~PDSCH (for both unicast and broadcast) and~~ PUSCH, down-select between the following options for the maximum number of contiguous PRBs:****• Option 1: 28 PRBs for 15 kHz SCS and 14 PRBs for 30 kHz SCS****• Option 2: 27 PRBs for 15 kHz SCS and 13 PRBs for 30 kHz SCS****• 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** |
| FUTUREWEI |  |  | We proposed 12 RBs for the at least the PUSCH. |
| Nokia, NSB | Y | Option 4 | In our view, we prefer to stay with the RAN4 numbers for channel bandwidth of 5 MHz.In the SI, we studied 11 vs 12 PRBs for 30 kHz SCS. However, the performance improvement shown in the SI is small. For PUSCH, we don’t see the need to support 12 PRBs for transform precoding as we can have a mix of different UE types in the same BWP. In addition, cell-edge UEs where DFT-S-OFDM would be beneficial would not be using more than few PRBs. Finally, the peak data rates can be met with 25/11 PRBs.In addition, it is important to support the same number of PRBs for PDSCH and PUSCH to avoid implementation complexity. |
| Qualcomm | Y | Option 3 | We are fine with the current proposal for now even though we prefer option 3. RAN1 assumed option 3 or option 4 for complexity and coverage analysis during the study item so we may choose one from the two options unless there is good justification for the other options. |

**Separate initial BWP**

Several contributions [9, 14, 15, 24, 28, 32, 33] propose that the initial DL/UL BWP operation framework for Rel-17 RedCap can be reused for Rel-18 RedCap. A few contributions [15, 28] express that there is no need to configure a separate initial BWP for Rel-18 RedCap UEs. One contribution [18] proposes to reuse MIB-configured initial DL BWP for Rel-18 RedCap. One contribution [24] proposes to discuss whether to support more than one initial DL/UL BWP.

**High Priority Proposal 2-2a: For UE BB bandwidth reduction, for a cell supporting both Rel-17 and Rel-18 RedCap UEs,**

* **The Rel-18 RedCap UEs can share the same separate 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**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon | Y | Not sure why additional initial DL/UL BWP specific to Rel-18 RedCap UEs is necessary. But OK for FFS at this stage. |
| Nordic  | Y | Hopefully “share” does not preclude R18 specific parameters in that BWP. |
| FL1 | Based on the proposal, the online (GTW) session on Monday 10th October made this agreement: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
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**Maximum span for the resource allocation**

Several contributions [10, 11, 16, 19, 21, 22, 25, 28, 29, 30, 32, 33, 34] discuss whether the resource allocation should span a bandwidth of maximum 5 MHz for PDSCH (for both unicast and broadcast) and PUSCH, or support distribution within 20 MHz bandwidth with a limitation of the maximum number of PRBs (at least for PDSCH). One contribution [25] suggests an approach where the PDSCH processing bandwidth is up to 5 MHz whereas the instantaneous PDSCH transmission bandwidth can be wider.

For unicast transmissions, some contributions [8, 9, 15, 33] propose that scheduled bandwidth does not exceed 5 MHz.

For broadcast PDSCH transmissions, some contributions [8, 15, 22, 25, 33] propose that the allocation can be larger than 5 MHz even though the UE only receives 5 MHz, whereas one contribution [24] expresses that the UE should not be expected to receive broadcast channels with wider bandwidth than 5 MHz. One contribution [9] proposes that this should apply for SIB but not for other broadcast transmissions, and a couple of contributions [26, 34] propose that the UE should receive the full bandwidth of some broadcast transmissions (e.g., SIB).

**High Priority Proposal 2-3a: For UE BB bandwidth reduction, for SIB1 (PDSCH) shared between Rel-18 RedCap UEs and other types of UEs, down-select between the following options:**

* **Option 1: Restrict the scheduling of SIB1 to be within 5 MHz**
* **Option 2: Allow the scheduling of SIB1 to be larger than 5 MHz (as in legacy operation)**

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| **Company** | **Y/N** | **Preferred option,if any** | **Comments** |
| Huawei, HiSilicon |  | Option 2 | Since 20Mhz SIB1 exists in current NR network and Rel-18 RedCap UEs are expected to share the same initial BWP with Rel-17 RedCap UEs, Option 1 seems not practical solution. |
| Nordic  | Y | Option 2 |  |
| FL1 | Based on the proposal, the online (GTW) session on Monday 10th October made this agreement:Agreement:For UE BB bandwidth reduction, for SIB1 (PDSCH) to Rel-18 RedCap UEs, down-select between the following options,* Option 1: Restrict the scheduling of SIB1 to be within 5 MHz
* Option 2: Allow the scheduling of SIB1 to be larger than 5 MHz (as in legacy operation)
* FFS: whether 5MHz is assumed to be physically contiguous
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**FL1 High Priority Proposal 2-4a: For UE BB bandwidth reduction, for paging channel (PDSCH) shared between Rel-18 RedCap UEs and other types of UEs, down-select between the following options:**

* **Option 1: Restrict the scheduling of paging channel to be within 5 MHz**
* **Option 2: Allow the scheduling of paging channel to be larger than 5 MHz (as in legacy operation)**

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| **Company** | **Y/N** | **Preferred option,if any** | **Comments** |
| Huawei, HiSilicon | Y | Option 1 | Paging is not periodic signaling as SIB1. Performance loss caused by option 2 needs careful consideration. |
| Nordic  | Y | Option 2 |  |
| MediaTek | Y | Option 2 | Our view is that transmission bandwidth for all broadcast PDSCHs should be allowed up to 20MHz as legacy operation. UE BB bandwidth reduction does not mean transmission bandwidth reduction at gNB. |
| FUTUREWEI | Y |  | Both options can further be discussed. |
| Nokia, NSB | Y | Option 2 | We share similar view as MediaTek. Option 2 would allow the gNB to page both Rel-18 RedCap and legacy UEs in the same message without performance impact to the legacy UEs. The gNB also would not need to be aware what UE type it is paging. We do not see the need for the network to be aware of or have separate broadcast transmission for Rel-18 RedCap versus legacy UEs. |
| Qualcomm | Y |  | Need further discussion between two options for paging. |

**FL1 High Priority Proposal 2-5a: For UE BB bandwidth reduction, for other broadcast PDSCH than SIB1 and paging (e.g., OSI, RAR), down-select between the following options:**

* **Option 1: Restrict the scheduling of broadcast PDSCH to be within 5 MHz**
* **Option 2: Allow the scheduling of broadcast PDSCH to be larger than 5 MHz (as in legacy operation)**

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| **Company** | **Y/N** | **Preferred option,if any** | **Comments** |
| Huawei, Hisilicon | Y | Option 1 |  |
| Nordic  | N |  | OSI can follow SIB1, but RAR may need to be confined to 5MHz, so those two should not be coupled together  |
| MediaTek |  | Option 2 | Our view is that transmission bandwidth for all broadcast PDSCHs should be allowed up to 20MHz. UE BB bandwidth reduction does not restrict transmission bandwidth at gNB.  |
| FUTUREWEI |  |  | Both options can be discussed. We are okay to separate both. |
| Nokia, NSB | Y | Option 2 | Similar comment as in 2-4a.We do not see the need for the network to be aware of or have separate broadcast transmission for Rel-18 RedCap versus legacy UEs.  |
| Qualcomm | N |  | We share the same view with Nordic that SI and RAR needs to be discussed separately. Option 2 is preferred for OSI following SIB1. However, if separate early indication is supported for Rel-18 eRedCap UE, option 1 is preferred for RAR. |

**FL1 High Priority Question 2-6a: For UE BB bandwidth reduction, can distributed resource allocation spanning more than 5 MHz be supported for unicast PDSCH/PUSCH? Please elaborate in the Comments field.**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon |  | Clarification is suggested for any difference between the proposal and the PR3 defined in the TR. |
| Nordic  | N | Not OK with this proposal for PUSCH, PUSCH must be contiguous. For PDSCH PR3 would make sense, as R18 RedCap could be then multiplexed with R17 RedCap in frequency domain.  |
| MediaTek | N | We share a similar view with Nordic. For PDSCH, PR3 vs BW3 should be revisited in RAN1. For PUSCH, we support contiguous resource allocation confining to 5MHz, i.e. BW3. |
| FUTUREWEI | N | We picked BW3 not PR3 and this is the main difference |
| Nokia, NSB | N | Our preference is BW3 so we do not support distributed resource allocation spanning more than 5 MHz. |
| Qualcomm | N | We prefer to keep resource allocation confined within 5MHz BW (BW3) as captured in WID. |

**Aspects related to impacts on broadcast channels**

Some contributions [15, 30] express that it should be possible to share broadcast PDSCH transmissions (e.g., SIB, OSI, RAR, Paging) between Rel-18 RedCap UEs and other UEs, and a few contributions [22, 29, 35] indicate that it is not necessary to specify coverage enhancements for channels that already support multiple transmissions (e.g., SIB1), since the UE implementation can rely on combination of the transmissions.

Some contributions [18, 24, 32] express that further discussion is needed regarding whether these broadcast PDSCH transmissions can be shared or may need to be separate. Some contributions [10, 14, 15, 20, 24, 33] propose to study whether further optimizations/enhancements for broadcast PDSCH are needed. One contribution [11] proposes to either restrict the bandwidth of the resource allocation of broadcast PDSCH transmission to 5 MHz or clarify the UE behavior when this bandwidth is larger than 5 MHz.

**FL1 High Priority Question 2-7a: For UE BB bandwidth reduction, considering the conclusions in TR 38.865 clause 8.2.4, should any enhancements or restrictions be specified to compensate for SIB1 link performance loss?**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon |  | Potential enhancement for SIB1 can be studied. But it seems too early to state that specification impact is needed.  |
| Nordic  |  | We could leave it up to implementation |
| FUTUREWEI | N | Compensation for SIB1 performance was not part of the WID |
| Nokia, NSB |  | We would like to study further potential enhancements for broadcast channels. |
| Qualcomm |  | We suggest discussing potential enhancements for broadcast channels.  |

**FL1 Medium Priority Question 2-8a: For UE BB bandwidth reduction, should any enhancements or restrictions be specified to compensate for link performance loss for other broadcast PDSCH transmissions than SIB1?**

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| **Company** | **Y/N** | **Comments** |
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**Scheduling optimizations for reducing post-FFT buffer complexity**

Several contributions [14, 17, 20, 21, 23, 28, 35] propose to consider whether the frequency location for PDSCH and/or PUSCH within the BWP can be indicated by semi-static configuration of the UE. A few contributions [14, 24, 29] propose to study solutions to facilitate post-FFT buffer reduction. For example, one contribution [23] proposes to consider DCI-based PRB subset switching to maintain frequency diversity, whereas one contribution [15] expresses that the UE can be dynamically allocated any frequency location within the BWP without any optimization.

**FL1 High Priority Proposal 2-9a: For UE BB bandwidth reduction, it is FFS whether/how to support semi-static indication of frequency location for PDSCH within the DL BWP for reducing the post-FFT buffer complexity.**

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| **Company** | **Y/N** | **Comments** |
| MediaTek |  | If BW3 (i.e. PDSCH resource allocation confining within 5MHz) is to be agreed, our view is that semi-static indication or pre-defined in spec should be supported. Considering it is the first meeting in WI, we have the following way-forward proposal:* **Proposal:** If BW3 is agreed, down-select from the following options for eRedCap UEs to determine which 5MHz “sub-band” is allocated for a unicast PDSCH
	+ Option 1: eRedCap UE knows which 5MHz “sub-band” is allocated for a unicast PDSCH before it decodes corresponding PDCCH
		- Option 1a: semi-static indication by RRC
		- Option 1b: pre-defined in specification
	+ Option 2: same slot unicast PDSCH scheduling, i.e. K0=0, is not supported by eRedCap UE.

Our understanding is that the 1% more complexity reduction that BW3 provided mainly was resulted from the assumption that UE had known which 5MHz “sub-band” would be scheduled beforehand, and post-FFT buffer size and DL receiver block reached more complexity reduction with BW3 than with PR3. If BW3 cannot reach more complexity reduction than PR3, we don’t see why to support a the more restricted BW3.  |
| FUTUREWEI |  | Both semi-static indication and cross-slot scheduling (proposal 2-10a) are approaches to reduce post-FFT buffer complexity. Both approaches have benefits and limitations. For semi-static indication, the network can use same-slot scheduling but the network may be restricted to using certain resources. From the UE side, the post-FFT buffer complexity is higher than with cross-slot scheduling as the UE must process both PDCCH and PDSCH (within a known region) in the same slot. We can consider “whether/how to support semi-static indication of frequency location” moving forward. |
| Nokia, NSB | N | In our view we do not see the need to support semi-static indication of frequency location for PDSCH within the DL BWP. In our view the potential complexity reduction would be small. However, this would restrict scheduler flexibility / increase complexity and also require considerable standardization effort. |
| Qualcomm | N | At least for SIB1 PDSCH, a UE has to support dynamic indication of frequency location if SIB1 PDSCH is shared between Rel-18 UEs and other type of UEs. Therefore, UE anyway has to support post-FFT buffering for 20MHz BWP until the DCI is correctly decoded. Then we do not understand how the semi-static indication of frequency location can reduce the post-FFT buffering complexity. Also semi-static indication of PDSCH frequency location limits the scheduling flexibility. We prefer to have dynamic indication of the actual resources inside the configured BWP. |

Some contributions [14, 16, 17, 26] bring up the possibility to use cross-slot scheduling (rather than same-slot scheduling) for unicast and/or broadcast for the purpose of facilitating reduction of the post-FFT data buffering.

**FL1 High Priority Proposal 2-10a: For UE BB bandwidth reduction, it is FFS whether/how to support cross-slot scheduling for PDSCH (for unicast and/or broadcast) for reducing the post-FFT buffer complexity.**

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| **Company** | **Y/N** | **Comments** |
| MediaTek |  | As commented in the above, if BW3 is agreed, we think UE should be able to know which 5MHz “sub-band” is allocated for a unicast PDSCH **before** it decodes the corresponding PDCCH, i.e. we support Option 1 (1a or 1b) in our proposal in the comments to FL1 High Priority Proposal 2-9a in the above. However, we are open to discuss cross-slot scheduling for now.  |
| FUTUREWEI |  | As we commented above, cross-slot scheduling allows processing of PDCCH and PDSCH in separate slots, lowers post-FFT buffer complexity, and provides the network flexibility to manage which resources to schedule. While current specifications indicate that broadcast PDSCH need same-slot scheduling, there are techniques to manage same slot-scheduling and should be discussed. We support “whether/how to support cross-slot scheduling” moving forward. |
| Nokia, NSB | N | We do not want to mandate cross-slot scheduling as this would restrict scheduler flexibility / increase complexity and also require considerable standardization effort. In our view the potential complexity reduction would be small. |
| Qualcomm |  | Cross-slot scheduling is already supported for unicast PDSCH in current spec so we do not need to discuss unicast PDSCH here. Then the proposal would be only for broadcast PDSCH with default TDRA table. We do not have preferences on supporting cross-slot scheduling for broadcast PDSCH as we have to consider the coexistence scenario that SIB1 PDSCH shared between Rel-18 UEs and other type of UEs.  |

**Frequency-domain resource allocation (FDRA) optimization**

A few contributions [19, 33, 35] suggest that FDRA optimization/enhancement can be considered. One contribution [16] proposes to consider dynamic indication of a 5-MHz region, where the FDRA is defined within this region. One contribution [29] proposes that FDRA for unicast can be based on 5-MHz sub-bands to save DCI overhead. One contribution [24] proposes to discuss potential reuse of spare bits from the FDRA field in the RAR UL grant.

**FL1 Medium Priority Question 2-11a: For UE BB bandwidth reduction, should any kind of FDRA optimization be considered for further study? Please elaborate your response in the Comments field.**

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| **Company** | **Y/N** | **Comments** |
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**Other aspects of UE BB bandwidth reduction**

* The same resources within 5 MHz and [≤10 MHz] are used for the duration of the slot [8].
* PUCCH and SRS are restricted to 5MHz, at least when PUSCH is present and FFS when PUSCH is not present; FFS for the 5 MHz restriction of RACH [8].
* Intra-slot or inter-slot frequency hopping within bandwidth larger than 5MHz can be supported for PUSCH (including Msg3 PUSCH) while keeping the 5 MHz maximum BW of each hop [9].
* Simultaneous reception of PDSCH (limited to 5MHz in baseband) and SSB/PDCCH/CSI-RS within the BWP is supported for BWP of up to 20 MHz; simultaneous reception of two PDSCH transmissions (e.g., unicast and broadcast) is supported. FFS UE behavior when total frequency allocation is larger than 5 MHz; simultaneous transmission of PUSCH (limited to 5MHz in baseband) and PUCCH within the BWP is supported for BWP of up to 20 MHz [15].
* The UE behavior for the reception of multiple simultaneous PDSCHs needs to be specified for Rel-18 RedCap UEs [20].
* Decide whether a Rel-18 RedCap UE can process two broadcast PDSCHs or one broadcast PDSCH plus one unicast PDSCH are FDM multiplexed in a slot [16].

# 3 UE peak data rate reduction

According to the WID [1], it should be checked in RAN#98-e whether the UE peak data rate reduction is limited to UEs with UE BB bandwidth reduction only or whether it can be a standalone feature.

* Several contributions [9, 10, 15, 16, 21, 24, 19, 20, 22, 30, 34] express that UE peak data rate reduction should only be supported as an add-on feature to the UE BB bandwidth reduction feature and not as a standalone feature, whereas other contributions [11, 13, 14, 17, 25, 27, 33] express that UE peak data rate reduction should be supported as a standalone feature.
* Some contributions [9, 10, 16, 21, 35] express that specifying a standalone UE peak data rate reduction feature would lead to introduction of multiple new UE types and/or fragment the ecosystem, whereas one contribution [33] expresses that it would not introduce additional UE types, would not have RAN1 specification impact, would facilitate early implementations, and would be beneficial for dual-mode LTE-NR devices, and finally one contribution [27] expresses that it might in fact improve the economies of scale.
* A couple of contributions [26, 35] conclude that the combination of UE BB bandwidth reduction and UE peak data rate reduction (e.g., to *vLayers*·*Qm*·*f* ≥1) would not meet the target of 10 Mbps peak rate indicated in the justification part of the WID [1]. A few contributions [11, 28] propose that the constraint (*vLayers*·*Qm*·*f* ≥ 4) is not relaxed at all. One contribution [27] expresses that the relaxed peak rate constraint shall be chosen such that the peak data is not less than 10 Mbps in downlink and 5 Mbps in uplink (as for LTE Cat-1).
* One contribution [10] expresses that UE peak data rate reduction can be considered as a standalone feature for FR2, whereas another contribution [8] expresses that this would not be in the Rel-18 WI scope.

Regarding the relaxation of the constraint (*vLayers*·*Qm*·*f* ≥ 4) for UE peak data rate reduction, the WID [1] suggests that it can be, e.g., 1 instead of 4 and that the parameters (*vLayers*, *Qm*, *f*) can be as in Rel-17 RedCap. Many contributions [9, 10, 11, 13, 14, 16, 17, 22, 25, 27, 30, 32, 33, 34] discuss what the relaxed value ought to be. As mentioned above, some contributions observe that the resulting peak rate will be much lower than 10 Mbps if the UE BB bandwidth reduction feature is combined with the UE peak data rate feature with a relaxed constraint of 1 instead of 4, and some of them suggest that a relaxed constraint of around 3 would be more suitable for meeting the targeted peak rate of 10 Mbps.

Based on the above considerations, the following proposal can be considered, where the square brackets indicate that the values are working assumptions which will be revisited.

**FL1 High Priority Proposal 3-1a:**

* **If UE peak data rate reduction is supported as an add-on to UE BB bandwidth reduction,**
	+ **The constraint *vLayers*·*Qm*·*f* ≥ 4 is relaxed to *vLayers*·*Qm*·*f* ≥ [3].**
* **If UE peak data rate reduction is supported as a standalone feature,**
	+ **The constraint *vLayers*·*Qm*·*f* ≥ 4 is relaxed to *vLayers*·*Qm*·*f* ≥ [1].**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon |  | OK for the first bullet. However, if two values are supported in the spec, it is unclear how one UE type of Rel-18 RedCap can be achieved considering additionally early identification is required. Therefore, we suggest to put the second bullet as FFS. |
| Nordic  | N | We should have single value agreed for R18 RedCap as WID states* + 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.
 |
| FUTUREWEI |  | We can accept with the "If", but given the SI conclusion the "add on" is both not so much in question and also falls more clearly in a single UE type. So from that perspective, also ok to just state that standalone is FFS |
| ~~Nokia, NSB~~ | ~~Y~~ | ~~We support the ability to have the same early indication to identify both Rel-17 and Rel-18 RedCap UE. We are fine to study further the ability to configure separate early indication for Rel-18 RedCap UE.~~ |
| Nokia, NSB | N | [Sorry, the above response was cut-and-paste error, correct response below]Agree with Nordic that we should only have one value. Our preference is to have UE peak data rate reduction as an add-on to UE BB bandwidth reduction as recommended by RAN1 in the TR.  |
| Qualcomm | N | We are fine with the proposal for standalone case. However, for the add-on case, *vLayers*·*Qm*·*f* = 3 does not meet 10Mbps peak rate with 12 PRB for 30KHz SCS so we prefer ***vLayers*·*Qm*·*f* ≥ 3.2.** **Alternatively**, we can also do like:* **If UE peak data rate reduction is supported as an add-on to UE BB bandwidth reduction,**
	+ **The constraint *vLayers*·*Qm*·*f* ≥ 4 is relaxed to *vLayers*·*Qm*·*f* ≥ X.**
	+ **X is the smallest possible value which meets 10Mbps for PDSCH/PUSCH for 15/30KHz SCS.**
* **If UE peak data rate reduction is supported as a standalone feature,**
	+ **The constraint *vLayers*·*Qm*·*f* ≥ 4 is relaxed to *vLayers*·*Qm*·*f* ≥ [1].**
 |

# 4 Early indication

**Early indication in Msg1/MsgA PRACH**

Several contributions [8, 10, 12, 18, 19, 21, 22, 28, 29, 33] express that a separate indication in Msg1/MsgA PRACH specifically for Rel-18 RedCap UEs can be supported, whereas other contributions [14, 15, 24, 31, 32, 35] want to study further whether the separate indication should be supported or not. Some contributions [9, 11, 16, 23] express that it is not necessary and/or should not be supported.

A few contributions [20, 27] express that separate early indication in Msg1 can be supported for UE BB bandwidth reduction, whereas the contribution [20] expresses that separate early indication specifically for the combination of UE BB bandwidth reduction and UE peak rate reduction should not be supported. The contribution [27] also expresses that early indication in Msg1 for standalone peak rate reduction needs further study, and that only one separate early indication should be specified for all Rel-18 RedCap UEs.

**Early indication in Msg3/MsgA PUSCH**

Some contributions [9, 15, 16, 22, 28] express that a separate early indication in Msg3 and/or MsgA PUSCH can be supported, whereas a few contributions [24, 35] want to study further whether the separate indication is supported or not. One contribution [11] expresses that the separate indication in Msg3 should not be supported. Another contribution [14] expresses that it should be up to RAN2 to decide whether/how to support Msg3 indication. A couple of contributions [20, 27] express that the separate indication can be supported for UE BB bandwidth reduction, but one contribution [27] wants to study further whether it should also be supported for standalone peak rate reduction.

**FL1 High Priority Proposal 4-1a: Rel-18 RedCap UEs (supporting UE complexity reduction functionality introduced by this WI) can use the same early indication in Msg1/Msg3/MsgA as Rel-17 RedCap UEs.**

* **FFS: whether to also support separate early indication in Msg1/Msg3/MsgA for Rel-18 RedCap UEs**

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| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon |  | In our view, this proposal is related to FL1 Proposal 2-5a. Therefore, we suggest to make more progress on RAR handling first and the issue of intra-slot hopping of Msg3 (whether the effective bandwidth after intra-slot hopping can exceed 5 MHz) before we discuss this proposal. |
| Nordic | Y | Agree with HW |
| MediaTek |  | More discussion and consensus are needed on broadcast PDSCHs and RACH messages before we can understand whether a separate early indication is indeed needed for Rel-18 eRedCap. |
| FUTUREWEI |  | Our understanding from RAN#97 was that we would at least support the possibility of same early indication, but from the GTW today we should probably craft a full proposal considering hopping, R18 when R17 is not present, etc. rather than have FFS. |
| Nokia, NSB | Y | We support the ability to configure the same early indication to identify both Rel-17 and Rel-18 RedCap UE. We are fine to study further the ability to configure separate early indication for Rel-18 RedCap UE. |
| Qualcomm | N | We prefer to define separate early indication for Rel-18 RedCap UEs in order to allow NW to choose the configuration between separate early indication or same early indication between Rel-18 UEs and Rel-17 UEs. We also agree that we need further discussion on broadcast channels. Rather than agreeing on the current proposal with FFS, it would be good to discuss broadcast channel discussion first and come back to the early indication discussion. |

**FL1 Medium Priority Question 4-2a: Is a separate early indication in Msg1 for Rel-18 RedCap UEs needed?**

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| **Company** | **Y/N** | **Comments** |
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**FL1 Medium Priority Question 4-3a: Is a separate early indication in Msg3 for Rel-18 RedCap UEs needed?**

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| **Company** | **Y/N** | **Comments** |
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# 5 Other aspects

**Cell barring**

* Rel-18 RedCap UE shares the same cell access/barring indication and mechanism with Rel-17 RedCap UE. FFS additional cell access/barring indication. Final decision is up to RAN2 [14].
* A broadcasted SI indicating network support for Rel-18 RedCap is needed; network may support Rel-17 RedCap UEs but not Rel-18 RedCap UE [27].
* Introduce a new cell bar and an IFRI field in SIB1 for RedCap UEs [22].

**SSB and CORESET#0**

* FFS introducing new or reused SSB or CORESET#0 for Rel-18 RedCap. FFS how to reuse Rel-15 SSB for Option BW3 [12].
* Reuse Rel-15 SS/PBCH block for cell search and measurements for Rel-18 RedCap [18].
* Specify support of NCD-SSB for RedCap UEs in idle/inactive mode [10].

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

* The basic feature group for Rel-18 RedCap includes BW3 [8].
* RAN1 defines one new Rel-18 RedCap UE type for further UE complexity reduction [15].
* Introduce new UE capability parameter for Rel-18 RedCap UEs that indicates basic functional components [15].
* BB bandwidth for PDSCH and PUSCH is an identification for the new RedCap UE type [22].
* Peak data rate reduction can be reported by the existing capability parameters *vLayers*, *Qm*and *f* [20].
* A single Rel-18 RedCap UE type should be supported for Rel-18 RedCap [12].

**Miscellaneous**

* Discuss whether to specify coverage recovery techniques for RedCap considering normal deployment scenario (i.e., not based on the Urban scenario at 4 GHz with 11 PRBs and DL PSD of 24dBm/MHz) and not considered the 3 dB antenna efficiency loss [24].
* Support/discuss enhancements for common PUCCH especially when the FH for the common PUCCH resources is disabled [24].
* For PUSCH, both CP-OFDM and DFT-s-OFDM should mandatorily be supported by RedCap UEs [30].
* For TDD, only the RF bandwidth for UL and DL needs to be aligned [15].
* Reduce BD/CCE limits for R18 Redcap UEs to half, i.e., 28CCE + 22BD per 15kHz slot, 18BDs per 30kHz SCS; Rel-18 RedCap UE monitors only one common SS per slot [34].
* DCI format sizes are the same as for legacy UEs [34].
* 16QAM is mandatorily supported while 64QAM can be optionally supported by Rel-18 RedCap [25].

# References

|  |  |  |  |
| --- | --- | --- | --- |
| [1] | [RP-222675](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_97e/Docs/RP-222675.zip) | New WID on enhanced support of reduced capability NR devices | Ericsson |
| [2] | [R1-2208361](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208361.zip) | WI work plan for Rel-18 RedCap | Rapporteur (Ericsson) |
| [3] | [R1-221163](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_96/Docs/RP-221163.zip) | Summary of [Rel-17] WI on support of reduced capability (RedCap) NR devices | Ericsson |
| [4] | [R1-2205427](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2205427.zip) | RAN1 agreements for Rel-17 NR RedCap | Rapporteur (Ericsson) |
| [5] | [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 |
| [6] | [RP-222633](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_97e/Docs/RP-222633.zip) | Moderator’s summary for discussion [97e-15-R18-RedCap] | Moderator (Ericsson) |
| [7] | [R1-2208362](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208362.zip) | Further RedCap UE complexity reduction | Ericsson |
| [8] | [R1-2208387](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208387.zip) | Discussion on details for R18 RedCap complexity techniques | FUTUREWEI |
| [9] | [R1-2208416](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208416.zip) | Discussion on potential solutions to further reduce UE complexity | Huawei, HiSilicon |
| [10] | [R1-2208560](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208560.zip) | Discussion on enhanced support of RedCap devices | Spreadtrum Communications |
| [11] | [R1-2208653](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208653.zip) | Discussion on UE further complexity reduction | Vivo, Guangdong Genius |
| [12] | [R1-2208775](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208775.zip) | Discussion on UE complexity reduction | China Telecom |
| [13] | [R1-2208842](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208842.zip) | Technologies for further reduced UE complexity | OPPO |
| [14] | [R1-2208986](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208986.zip) | Discussion on further complexity reduction for eRedCap UE | CATT |
| [15] | [R1-2209004](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209004.zip) | RedCap UE Complexity Reduction | Nokia, Nokia Shanghai Bell |
| [16] | [R1-2209062](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209062.zip) | Discussion on complexity reduction for eRedCap UE | Intel Corporation |
| [17] | [R1-2209109](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209109.zip) | UE complexity reduction for eRedCap | Sony |
| [18] | [R1-2209163](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209163.zip) | Discussion on Rel-18 RedCap UE | NEC |
| [19] | [R1-2209170](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209170.zip) | Discussion on UE complexity reduction | Transsion Holdings |
| [20] | [R1-2209194](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209194.zip) | Discussion on further UE complexity reduction | ZTE, Sanechips |
| [21] | [R1-2209221](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209221.zip) | UE complexity reduction | Lenovo |
| [22] | [R1-2209295](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209295.zip) | Discussion on further complexity reduction for eRedCap UEs | Xiaomi |
| [23] | [R1-2209347](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209347.zip) | Discussion on further UE complexity reduction | CMCC |
| [24] | [R1-2209451](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209451.zip) | Discussion on further UE complexity reduction for eRedCap | LG Electronics |
| [25] | [R1-2209519](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209519.zip) | On further UE complexity reduction for RedCap | MediaTek Inc. |
| [26] | [R1-2209591](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209591.zip) | Discussion on further RedCap UE complexity reduction | Apple |
| [27] | [R1-2209663](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209663.zip) | Considerations for further UE complexity reduction | Sierra Wireless. S.A. |
| [28] | [R1-2209684](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209684.zip) | Discussion on UE complexity reduction | Sharp |
| [29] | [R1-2209741](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209741.zip) | Further UE complexity reduction for eRedCap | Samsung |
| [30] | [R1-2209791](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209791.zip) | UE complexity reduction for eRedCap | Panasonic |
| [31] | [R1-2209866](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209866.zip) | Discussion on UE complexity reduction | DENSO CORPORATION |
| [32] | [R1-2209912](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209912.zip) | Discussion on further UE complexity reduction for eRedCap | NTT DOCOMO, INC. |
| [33] | [R1-2209995](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209995.zip) | UE complexity reduction for eRedCap | Qualcomm Incorporated |
| [34] | [R1-2210196](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2210196.zip) | On further complexity reduction of NR UE | Nordic Semiconductor ASA |
| [35] | [R1-2210283](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2210283.zip) | Further RedCap UE complexity reduction(revision of [R1-2208362](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208362.zip)) | Ericsson |
| [36] | [R1-221024](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2210248.zip) | FL summary #1 on Rel-18 RedCap UE complexity reduction | Moderator (Ericsson) |