3GPP TSG-RAN WG1 Meeting #107-e Draft R1-2112497

e-Meeting, 11th – 19th November 2021

**Agenda Item: 8.6.1.1**

**Title: FL summary #1 on reduced maximum UE bandwidth for RedCap**

**Source: Moderator (Ericsson)**

**Document for: Discussion, Decision**

# Introduction

This feature lead (FL) summary (FLS) concerns the Rel-17 work item (WI) for support of reduced capability (RedCap) NR devices [1]. Earlier RAN1 agreements for this WI are summarized in [2]. The final FLS for this agenda item from the previous RAN1 meeting can be found in [3].

This document summarizes contributions [4] – [29] submitted to agenda item 8.6.1.1 and relevant parts of contributions [30] – [36] submitted to other agenda items and captures this email discussion on reduced maximum UE bandwidth:

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| [107-e-NR-R17-RedCap-01] Email discussion regarding aspects related to reduced maximum UE bandwidth – Johan (Ericsson)   * 1st check point: November 15 * Final check point: November 19 |

RAN1 is waiting for LS responses from RAN2 and RAN4 to an LS on NCD-SSB sent from RAN1#106bis-e [37]. This is discussed in Section 5 (“SSB transmission”) in this document.

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 in this meeting are furthermore tagged FL1.

Follow the naming convention in this example:

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

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

* Assume CompanyC wants to update *RedCapBwFLS-v002-CompanyA-CompanyB.docx*.
* CompanyC uploads an empty file named *RedCapBwFLS-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 *RedCapBwFLS-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 10 in [R1-2110752](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2110752.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.**

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| **Company** | **Point of contact** | **Email address** |
| Intel Corporation | Debdeep Chatterjee | debdeep.chatterjee@intel.com |
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# Separate initial UL BWP

RAN1#106bis-e [2] made the following agreement regarding separate initial UL BWP:

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| Agreement:   * For a cell that allows a RedCap UE to access, network can configure a separate initial UL BWP for RedCap UEs in SIB   + It can be used both during and after initial access.   + It is no wider than the maximum RedCap UE bandwidth.   + It is always configured if the initial UL BWP for non-RedCap UEs is wider than the maximum RedCap UE bandwidth   + This applies to both TDD and FDD (including FD FDD and HD FDD) cases |

In RAN1#106bis-e [3], there was a discussion on whether up to 2 separate initial UL BWPs can also be configured for RedCap:

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| High Priority Proposal 2.1-2d:   * It is FFS till RAN1#107-e whether up to 2 separate initial UL BWPs can also be configured. |

Several contributions [4, 8, 15, 16, 17, 28] indicate that only one separate initial UL BWP is configured for RedCap in Rel-17. These contributions argue that having more than one separate initial UL BWP for RedCap has a limited motivation while it results in PUSCH resource fragmentation, additional overhead, and complicated UL/DL BWP configuration especially when TDD centre frequency alignment is desired. However, a few contributions express that up to 2 initial UL BWPs should be configured for RedCap to be able to share 8 FDMed ROs between RedCap and non-RedCap UEs [5, 6, 12].

**FL1 High Priority Question 2-1a: How many separate initial UL BWPs for RedCap can be configured?**

* **Option 1: Up to 1 separate initial UL BWP for RedCap can be configured.**
* **Option 2: Up to 2 separate initial UL BWPs for RedCap can be configured.**

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| **Company** | **Option (1/2)** | **Comments** |
| Intel | 1 | Up to one separate initial UL BWP for RedCap is sufficient.  It is not justified to introduce significant complications to the RedCap BWP framework with support of more than one separate initial UL BWP, only to support the case of max number of FDM-ed ROs in some configurations that may exceed max RedCap UE BW.  The option of separately configuring ROs for RedCap UEs (that need not be shared with non-RedCap UEs and need not all be multiplexed via FDM as for non-RedCap UEs) in a separate initial UL BWP that is limited to within RedCap UE max BW is sufficient.  The RedCap BWP framework is already far from having a stable design with consideration of a single separate initial UL BWP; extending this further for a corner case would not be a prudent choice. |
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# Separate initial DL BWP

Related to configuring/defining a separate initial DL BWP for RedCap UEs, we have the following working assumption in RAN1#105-e [2]:

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| Working assumption:   * At least for TDD, an initial DL BWP for RedCap UEs (which is not expected to exceed the maximum RedCap UE bandwidth) can be optionally configured/defined separately from the initial DL BWP for non-RedCap UEs at least after initial access   + FFS the details of the configuration/definition     - The configuration for a separately configured initial DL BWP for RedCap UEs is signaled in SIB.     - whether to support that separate initial DL BWP for RedCap UEs can include a configuration of CORESET and CSS(s)     - whether part of the configuration can be defined instead of signaled   + If a separate initial DL BWP for RedCap UEs is configured/defined, this separate initial DL BWP for RedCap UEs can be used at least after initial access (i.e., at least after RRC Setup, RRC Resume, or RRC Reestablishment).     - FFS during the initial access   + FFS: whether a separately configured initial DL BWP for RedCap UEs needs to contain the entire CORESET #0, and, if not, the RedCap UE behaviour for CORESET #0 monitoring   + FFS: supported bandwidths in the separate initial DL BWP   + FFS: whether additional SSB is transmitted in the separately configured initial DL BWP for RedCap UEs   + FFS: FDD case |

The working assumptions from RAN1#106bis-e [2] are as follows:

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| Working Assumption:   * For a cell that allows a RedCap UE to access, network can configure a separate initial DL BWP for RedCap UEs in SIB.   + Working assumption: It can be used during initial access   + It can be used after initial access.   + It is no wider than the maximum RedCap UE bandwidth.   + FFS: It is always configured if the initial DL BWP for non-RedCap UEs is wider than the maximum RedCap UE bandwidth.   + This applies to both TDD and FDD (including FD FDD and HD FDD) cases.   + Working assumption: It applies at least after initial access for FR1 when MIB configured CORESET#0 is included |

The contributions generally agree that configuring/defining a separate initial DL BWP for RedCap UEs is beneficial for flexibility and/or offloading purposes and also it is needed in scenarios where non-RedCap initial DL BWP is larger than the RedCap UE bandwidth (e.g., [4, 8, 10, 14, 15, 16, 17, 22, 23, 24, 28, 29]). Moreover, most of the contributions propose to confirm the working assumptions from RAN1#106bis-e related to the configuration of a separate initial DL BWP for RedCap. It was also proposed that such configuration applies to both FR1 and FR2 [4].

Regarding “FFS: It is always configured if the initial DL BWP for non-RedCap UEs is wider than the maximum RedCap UE bandwidth”, the contributions express different views. Two contributions [17, 29] indicate that the separate initial DL BWP for RedCap is always configured if the initial DL BWP for non-RedCap UEs is wider than the maximum RedCap UE bandwidth. Meanwhile, several contributions [4, 10, 14, 15, 19, 24, 25] argue it is not necessary to always configure a separate initial DL BWP for RedCap. Specifically, if the separate initial DL BWP for RedCap UEs is not configured, then the RedCap UEs may assume the MIB-configured CORESET#0 bandwidth as the initial DL BWP:

* [15]: There is no need to mandate separate initial DL BWP configuration for RedCap when the SIB-configured BWP#0 is larger than the maximum RedCap UE bandwidth.
* [19]: If SIB1-configured initial DL BWP has a wider bandwidth than the maximum RedCap UE bandwidth and additional initial DL for RedCap UEs is not configured, a RedCap UE derives initial DL BWP corresponding to CORESET#0.
* [24]: If the separate initial DL BWP for RedCap UEs is not configured, then the RedCap UEs may assume the MIB-configured CORESET#0 bandwidth as the initial DL BWP.
* [25]: When the parameter on the separate initial DL BWP is absent, a RedCap UE use the BW of CORESET#0 or configuration of initial DL BWP for non-RedCap.

Based on the above views, the following proposal and question related to the RedCap separate initial DL BWP can be considered.

**FL1 High Priority Proposal 3-1a: The following working assumptions related to the separate initial DL BWPs for RedCap are confirmed for both FR1 and FR2:**

* **Working Assumption: For a cell that allows a RedCap UE to access, network can configure a separate initial DL BWP for RedCap UEs in SIB.**
  + **Working assumption: It can be used during initial access**
  + **It can be used after initial access.**
  + **It is no wider than the maximum RedCap UE bandwidth.**
  + **This applies to both TDD and FDD (including FD FDD and HD FDD) cases.**
  + **Working assumption: It applies at least after initial access for FR1 when MIB configured CORESET#0 is included**

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| **Company** | **Y/N** | **Comments** |
| Intel | Y (see comments) | While we can confirm the working assumptions, the case not covered by the last working assumption needs to be addressed as well.  To elaborate, if the initial DL BWP is used during initial access, e.g., if PDCCH Type 1 CSS for random access is configured in the separate initial DL BWP, but MIB-configured CORESET #0 is not included within the separate initial DL BWP, the RedCap UE should continue to receive DL in the separate initial DL BWP after RRC connection establishment (“after initial access”).  Moreover, if any other PDCCH CSS (Types 0/0A/2) are (optionally) configured in the separate initial DL BWP, the RedCap UE can receive the corresponding common control in the separate initial DL BWP if the latter is included within its active DL BWP when in RRC\_CONNECTED mode.  Thus, if a separate initial DL BWP is configured to RedCap UE, it should be applicable for reception by RedCap UEs after initial access regardless of whether MIB-configured CORESET #0 is included or not. |
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**FL1 High Priority Question 3-2a: Should a separate SIB-configured initial DL BWP for RedCap always be configured if the initial DL BWP for non-RedCap UEs is wider than the maximum RedCap UE bandwidth?**

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| **Company** | **Y/N** | **Comments** |
| Intel | N | The initial DL BWP for non-RedCap UEs, provided via SIB1, can be larger than max RedCap UE BW. If NOT configured with a separate initial DL BWP for RedCap, a RedCap UE ignores the “*locationAndBandwidth*” configuration for the initial DL BWP and continues to receive in the DL in the initial DL BWP defined by CORESET #0. Note that rest of the configuration for the initial DL BWP in SIB1 applies to RedCap UEs as when in Idle/Inactive modes. |
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**Regarding the presence of CORESET#0 and other CORESETs/CSSs in the separate initial DL BWP:**

Based on the latest feature lead summary in RAN1#106bis-e [3], the following aspects are under discussion:

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| High Priority Proposal 3.2-5-1a:  For FR1,   * If a separate SIB-configured initial DL BWP for RedCap UEs is configured,   + It contains at least one CORESET and at least one CSS.   + It can be used both during and after initial access. * FFS: However, if it contains the entire CORESET#0, the RedCap UE shall use the bandwidth and location of the CORESET#0 in DL during initial access. |

Many contributions propose that a separate SIB-configured initial DL BWP for RedCap (if configured) does not need to contain the entire CORESET#0 [4, 5, 10, 14, 15, 17, 19, 22, 24, 25]. Also, several contributions mention that the separate initial DL BWP for RedCap UEs can include a configuration of CORESETs and CSS(s) [4, 5, 8, 10, 12, 14, 16, 17, 21, 22, 23]. In addition, several contributions [4, 11, 23] mention that if the separate initial DL BWP contains the entire CORESET#0, the RedCap UE shall use the bandwidth and location of the CORESET#0 in DL during initial access.

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

* **For FR1 and FR2, if a separate SIB-configured initial DL BWP for RedCap UEs is configured,**
  + **It contains at least one CORESET and at least one CSS.**
  + **It may or may not contain the entire MIB-configured CORESET#0.**
    - **If it contains the entire CORESET#0, the RedCap UE shall use the bandwidth and location of the CORESET#0 in DL during initial access.**

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| **Company** | **Y/N** | **Comments** |
| Intel | Y |  |
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**Supported bandwidths in the separate initial DL BWP:**

There are only a few views on the supported bandwidth of the separate initial DL BWP:

* [4]: For RedCap UEs the bandwidth of the separate initial DL BWP can have any value up to the maximum UE bandwidth (i.e., 20 MHz in FR1 and 100 MHz in FR2).
* [7]: The supported bandwidths in the separate initial DL BWP for RedCap UEs can have any values up to the maximum UE bandwidth.
* [15]: If the separate initial DL BWP is configured by SIB1, limit the supported bandwidth to relieve the capacity limitation in SIB1.
* [16]: For RedCap UE being configured with separate initial DL/UL BWP, fallback DCI size for RedCap UE is determined by down-selected following alternatives:
  + Alt 1: Fallback DCI size for RedCap UE is the same as legacy Rel-15/16 which is determined by CORESET#0.
  + Alt 2: Fallback DCI size for RedCap UE can be determined by separate initial UL/DL BWP for RedCap UE.

Based on the presented views, the bandwidth of a separate initial DL BWP can be either be flexible (i.e., various values up to the RedCap UE bandwidth) or limited to a set of pre-defined values such as CORESET#0 bandwidths.

**Medium Priority Question 3-4a:**

* **For a separate initial DL BWP for RedCap UEs, what bandwidths should be supported?**
  + **Option A: The supported bandwidths for the separate initial DL BWP for RedCap UEs can have any values up to the maximum UE bandwidth (as in legacy operation).**
  + **Option B: The supported bandwidths for the separate initial DL BWP for RedCap UEs must be limited to a set of pre-defined values such as CORESET#0 bandwidths.**

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| **Company** | **Option (A/B)** | **Comments** |
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# BWP center frequency

RAN1#106bis-e [2] made the following agreement related to center frequencies for DL/UL BWPs in TDD:

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| Agreement:  For FR1,   * For TDD, center frequencies are assumed to be the same for the initial DL (FFS: if it does not include CD-SSB and the entire CORESET#0) and UL BWPs used during random access for RedCap UEs.   + FFS: For Option 1 and Option 2, whether the case that the center frequencies are different is also supported, and whether RedCap UE can expect CD-SSB and CORESET#0 in this case * For TDD, center frequencies are assumed to be the same for non-initial DL and UL BWPs with the same BWP id for a RedCap UE. |

Several contributions support/accept having the possibility of separate TDD center frequencies for initial UL/DL BWPs [4, 5, 7, 16, 17, 19, 22, 25, 26]. Moreover, these contributions mention that TDD center frequency alignment can depend on the scenario that whether the initial DL BWP contains SSB and/or CORESET#0. However, some other contributions indicate that the same center frequency is preferred to be maintained for initial UL/DL BWPs [12, 14, 15]. One contribution proposes to confirm that CORESET#0 does not need to be aligned in center frequency with (separate) initial UL BWP, for both BWP-configuration Option 1 and Option 2.

* [4]: With the support of separate center frequencies for initial UL/DL BWPs in TDD during initial access, all concerns regarding the PUSCH resource fragmentation and the presence of SSB and CORESET#0 within the initial DL BWP are resolved.
* [4]: For TDD, RAN 1 should down-select between the following cases for RedCap:
  + Case 1: The center frequencies for initial UL/DL BWPs can be different, but the initial DL BWP always contains the CORESET#0 and SSB.
  + Case 2: The center frequencies for initial UL/DL BWPs are always the same, but the initial DL BWP does not necessarily contain CORESET#0.
* [7]: The center frequencies are assumed to be the same for the initial DL (if it does not include CD-SSB and the entire CORESET#0) and UL BWPs used during random access for RedCap UEs. The center frequencies can be different for the initial DL (if it includes CD-SSB and the entire CORESET#0) and UL BWPs used during random access for RedCap UEs.
* [14]: For TDD, center frequencies are assumed to be the same for the initial DL BWP and initial UL BWP used during random access, regardless of whether the initial DL BWP includes CD-SSB and entire CORESET#0 or NOT.
* [15]: Assume the same center frequency for the initial DL and UL BWPs in all cases.
* [17]: For Option 1, the case that the center frequencies of initial BWPs are different is not supported. For Option 2, the case that the center frequencies of initial BWPs are different is supported, and RedCap UE can expect CD-SSB and CORESET#0 in this case.
* [19]: For initial DL/UL BWPs during initial access procedure, the RF-retuning latency and power consumption maybe acceptable from UE complexity perspective due to the less frequent operation and relaxed processing time requirement.
* [19]: Different central frequencies of separate initial DL/UL BWP during random access can be considered if separate initial DL BWP for RedCap includes CD-SSB and CORESET#0.
* [22]: For TDD, the center frequency can be different for the initial BWPs during random access.
* [25]: Support the case that center frequency for initial DL BWP including MIB configured CORESET#0 and separate initial UL BWP for RedCap UEs can be different.
* [25]: Center frequency should be assumed to be the same for initial DL BWP not including MIB configured CORESET#0 and separate initial UL BWP for RedCap UEs.
* [26]: For TDD, center frequencies are different for DL and UL BWPs with the same BWP id for RedCap UE.

Based on the expressed views, the following proposal can be considered.

**FL1 High Priority Proposal 4-1a:**

* **The center frequency of the MIB-configured CORESET#0 and the initial UL BWP may or may not be aligned.**

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| **Company** | **Y/N** | **Comments** |
| Intel | N | We suggest qualifying the proposal as below:   * **For TDD, the center frequency of the MIB-configured CORESET#0 and the initial UL BWP may or may not be aligned:**   + **if the MIB-configured CORESET #0 and initial UL BWP do not span a bandwidth larger than maximum RedCap UE BW, or**   + **if the UE is provided with configuration of Type 1 PDCCH CSS for random access in a separate initial DL BWP with same center frequency as initial UL BWP.**   Without the above qualifiers, the proposal implies that RedCap UE should support RF retuning between initial DL and UL BWPs. In such a case, we need to revert the decision from last meeting for consistency - there would be no benefit in forcing NW to configure separate initial DL BWP to align center frequency with initial UL BWP for TDD.  On the other hand, if center frequency between separate initial DL BWP and initial UL BWP are to be aligned when separate initial DL BWP does NOT include MIB-configured CORESET #0, it is not clear how the presence of MIB-configured CORESET #0 within the initial DL BWP affects handling of different center frequencies between DL and UL BWPs when these are used for random access. |
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**FL1 High Priority Proposal 4-2a:**

* **For FR1,**
  + **For TDD, the center frequencies are assumed to be the same for the initial DL (if it does not include CD-SSB and the entire CORESET#0) and UL BWPs used during random access for RedCap UEs.**
  + **For TDD, the center frequencies can be different for the initial DL (if it includes CD-SSB and the entire CORESET#0) and UL BWPs used during random access for RedCap UEs.**

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| **Company** | **Y/N** | **Comments** |
| Intel | N | As explained in response to **Proposal 4-1a**, the second sub-bullet is not acceptable as the two bullets are not consistent in terms of expectations from the UE. Presence of CD-SSB/CORESET #0 does NOT impact retuning behavior between DL and UL BWPs in relation to the respective center frequencies.  We can accept the following version:   * **For FR1,**   + **For TDD, the center frequencies are assumed to be the same for the initial DL ~~(if it does not include CD-SSB and the entire CORESET#0)~~ and UL BWPs used during random access for RedCap UEs.**   + **~~For TDD, the center frequencies can be different for the initial DL (if it includes CD-SSB and the entire CORESET#0) and UL BWPs used during random access for RedCap UEs.~~** |
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**FL1 High Priority Question 4-3a:**

* **For FR2, can the following (which is copied from FR1 Proposal 4-2a) apply?**
  + **For TDD, the center frequencies are assumed to be the same for the initial DL (if it does not include CD-SSB and the entire CORESET#0) and UL BWPs used during random access for RedCap UEs.**
  + **For TDD, the center frequencies can be different for the initial DL (if it includes CD-SSB and the entire CORESET#0) and UL BWPs used during random access for RedCap UEs.**
* **If the answer to the question is different for different SSB/CORESET#0 multiplexing patterns, please elaborate in the Comments field.**

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| **Company** | **Y/N** | **Comments** |
| Intel | N | We agree with the same handling for FR1 and FR2.  We also support NOT optimizing for particular SSB/CORESET #0 patterns.  However, for the same reasons as described in responses to **Proposal 4-1a and Proposal 4-2a**, we can accept the above proposal with the following modifications.   * **For FR2, can the following (which is copied from FR1 Proposal 4-2a) apply?**   + **For TDD, the center frequencies are assumed to be the same for the initial DL ~~(if it does not include CD-SSB and the entire CORESET#0)~~ and UL BWPs used during random access for RedCap UEs.**   + **~~For TDD, the center frequencies can be different for the initial DL (if it includes CD-SSB and the entire CORESET#0) and UL BWPs used during random access for RedCap UEs.~~** |
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# SSB transmission

The contributions express views on transmission of additional SSBs in a separate initial DL BWP and RRC-configured DL BWP related to the following two options (Option 1 and Option 2) discussed in RAN1#106bis-e [3].

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| * For FR1, following options:   + Option 1:     - For a separate initial DL BWP (if it does not include CD-SSB and the entire CORESET#0),       * RedCap UE does NOT expect it to contain SSB/CORESET#0/SIB.     - For an RRC-configured active DL BWP (if it does not include CD-SSB and the entire CORESET#0),       * RedCap UE does NOT expect it to contain SSB/CORESET#0/SIB.   + Option 2:     - For a separate initial DL BWP (if it does not include CD-SSB and the entire CORESET#0),       * If it is configured for random access while not for paging in idle/inactive mode, RedCap UE does NOT expect it to contain SSB/CORESET#0/SIB.         + FFS: For BWP#0 configuration option 1, whether the UE can expect SSB transmission in the separate initial DL BWP when it is used in connected mode.       * If it is configured for paging, RedCap UE expects it to contain NCD-SSB for serving cell but not CORESET#0/SIB.     - For an RRC-configured active DL BWP in connected mode (if it does not include CD-SSB and the entire CORESET#0),       * RedCap UE expects it to contain NCD-SSB for serving cell [FFS: or CSI-RS or measurement gap configuration] but not CORESET#0/SIB.   + Note: if a separate initial/RRC configured DL BWP is configured to contain the entire CORESET#0, CD-SSB is expected by RedCap UE.   + Note: The network may choose to configure SSB or MIB-configured CORESET#0 or SIB1 to be within the respective DL BWP.   + FFS: For Option 1 and Option 2, whether RedCap UE can/cannot expect SSB under certain other conditions, e.g., for SSB monitoring periodicity (i.e., SMTC configuration) and DRX cycle   + FFS: Whether additional mechanism for SI update or how SI update notifications and/or SI updates are signaled to RedCap UEs   + FFS: FR2 case |

RAN1#106bis-e sent an LS [37] to RAN2 and RAN4 with the following questions related to SSB transmission:

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| 1. [RAN2/4] whether it is feasible to use NCD-SSB for serving and non-serving cell measurements for idle, inactive, and/or connected mode for all or some of RRM, RLM, BFD, link recovery, RO selection, mobility, time/frequency tracking and AGC 2. [RAN2/4] whether it is feasible to use NCD-SSB as QCL source of other DL channels/signals and as spatial relation (for UL channels/signals) transmitted in idle, inactive, and/or connected mode in the initial/non-initial DL BWP of RedCap UE 3. [RAN2] whether/when the PCIs indicated by the NCD-SSB and CD-SSB can be the same/different, if both NCD-SSB and CD-SSB are transmitted on the serving cell of RedCap UE 4. [RAN2/4] whether/when periodicities and/or TX power and/or block indexes (provided by *ssb-PositionsInBurst* in SIB1 or in *ServingCellConfigCommon*) and/or QCL sources of NCD-SSB can be same/different from those of CD-SSB, if both NCD-SSB and CD-SSB are transmitted on the serving cell of RedCap UE 5. [RAN2/4] whether it is necessary to introduce configuration limitations for NCD-SSB (e.g., regarding frequency locations, periodicity), e.g., to ensure coexistence with legacy UEs 6. [RAN2/4] if CD-SSB is not transmitted in the non-initial DL BWP of RedCap UE, whether it is feasible to transmit periodic CSI-RS for UE to use as an alternative of SSB in the non-initial BWP of RedCap UE or rely on UE performing RF retuning as in measurement gap outside active BWP for BWP without SSB nor CORESET#0 operation 7. [RAN2/4] whether it is feasible for a RedCap UE to retune to a CD-SSB rather than use an NCD-SSB of larger periodicity 8. [RAN2/4] any other potential impacts identified by RAN2/4 on support NCD-SSB for measurement |

RAN2#116-e has yet to reply to the LS from RAN1 but has already confirmed the following understanding of the current situation ([draft notes](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_116-e/Inbox/Chairmans_Notes/RAN2-116-e%20-%20R17%20NTN-REDCAP-CE_2021_11_10_0600.docx)):

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| RAN2 confirmed understanding of the current situation:  (FFS if any of the following will be included in a reply LS to RAN1)  1. For idle/inactive UEs, the concept of non-cell-defining SSB (NCD-SSB) and the corresponding procedures, i.e., measurements, cell (re-)selection, do not exist in the current RAN2 specifications.  2. For idle/inactive UEs, using NCD-SSB for measurements and cell (re-)selection would still require the UE to re-tune to the CORESET#0 for reading SIBs.  3. In connected mode, current RRC signalling allows configuring SSB-based RRM measurements on any (CD- or NCD-) SSB, but it does not allow using an NCD-SSB for RLM, BFD, link recovery, RO selection, mobility (mobility here refers to the frequency indicated in *FreqDLInfo* in HO command), in TCI-states or for any other functionality (other than RRM measurements).  4. It would be feasible to inform IDLE, INACTIVE and CONNECTED UEs about a NCD-SSB, however it is up to RAN1 and RAN4 to decide whether it is possible to use a NCD-SSB as QCL source.  5. According to the current RRC specification, PCIs indicated by other SSB and CD-SSB may be either the same or different if both other SSB and CD-SSB are transmitted on the serving cell.  6. PCIs indicated by the NCD-SSB and CD-SSB should be configured as same if both NCD-SSB and CD-SSB are transmitted on the serving cell.  7. According to the current RRC specification, periodicities and/or TX power and/or block indexes (provided by *ssb-PositionsInBurst* in SIB1 or in *ServingCellConfigCommon*) and/or QCL sources of other SSB may be either the same or different from those of CD-SSB, if both other SSB and CD-SSB are transmitted on the serving cell.  8. Use of CSI-RS for cell and beam RLM and measurements is already supported from RAN2 signaling standpoint. |

RAN4#101-e has yet to reply to the LS from RAN1 but has made the following agreements in GTW sessions the 2nd and 9th November 2021 ([draft notes](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_101-e/Inbox/Chairman_Notes/RAN4_101-e_RRM_session_report_09_Nov_10.docx)):

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| * Agreements:   + It is feasible to use NCD-SSB for serving and non-serving cell measurements for idle, inactive, and/or connected mode for all or some of RRM, RLM, BFD, link recovery, RO selection, mobility, time/frequency tracking and AGC     - FFS for specific conditions when it is feasible to use NCD-SSB     - It is RAN4 understanding that NCD-SSB measurements support may require additional signalling which is up to RAN2 * Agreements:   + Periodicities of NCD-SSB are up to network configuration and can be same or different from those of CD-SSB, if both NCD-SSB and CD-SSB are transmitted on the serving cell of RedCap UE. Periodicity of NCD-SSB shall be not less than periodicity of CD-SSB.   + TX power of NCD-SSB can be same or different from those of CD-SSB     - If TX power is different, then UE needs to be informed on the power difference between NCD-SSB and CD-SSB     - It is RAN4 understanding that if power boosting is used for CD-SSB then it may not be always possible to use the same TX power for NCD-SSB. |

The majority of the contributions agree that at least for FR1, Option 2 can be a compromise regarding the presence of SSB in the DL BWPs [4, 7, 9, 12, 15, 17, 19, 21, 24, 25, 26, 27, 28, 29]. Meanwhile, a few contributions do not support mandatory transmission of additional SSBs and prefer Option 1 [5, 11, 18]. One contribution [4] points out the significant overhead of additional SSB transmissions in FR2 and propose to support Option 1 for FR2. Meanwhile, one contribution [25] indicates that Option 2 should be supported for FR1 and FR2.

Two contributions [4, 5] mention that whether RedCap UE can/cannot expect SSB could be based on conditions such as SSB monitoring periodicity (i.e., SMTC configuration), DRX cycle, and measurement gap.

Moreover, related to the use of CSI-RS or measurement gap configuration instead of NCD-SSB in connected mode, the following views are presented:

* [4]: It may not be always feasible to use CSI-RS and/or measurement gaps instead of NCD-SSB.
* [17]: CSI-RS can be an alternative of NCD-SSB and has benefit in reducing network overhead.
* [18]: CSI-RS is used for RLM/BFD if there is no SSB transmission in the DL BWP.
* [27]: At least in FR1, CSI-RS should NOT be used as an alternative to SSB in RRM/BFD.

Given the tight timeline for the RAN1 work, the FL would like to ask the following question even though LS replies from RAN2 and RAN4 have not been received yet, since company positions may already have been affected by the preliminary assessments described above.

**FL1 High Priority Question 5-1a: For FR1, which option is preferred, and which options are acceptable to you?**

* **Option 1 (defined as in the text box in the beginning of this section of this document)**
* **Option 2 (defined as in the text box in the beginning of this section of this document)**
* **Other option (please describe in the Comments field)**

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| --- | --- |
| **Company** | **Comments** |
| Template | Preferred: Option X  Acceptable: Option X, Y |
| Intel | Preferred: Option 2  Acceptable: Option 2.  Given the discussions so far, we think Option 2 offers the best compromise and it would not be worthwhile to bring back Option 1 again. The discussions so far in RAN2 and RAN4 clearly point towards fundamental feasibility of supporting Option 2.  Although we acknowledge feasibility of Option 1, we do not think this would be the right way forward towards wrapping up the WI this meeting considering the prior discussions and the current situation in RAN1. |

**FL1 High Priority Question 5-2a: For FR2, which option is preferred, and which options are acceptable to you?**

* **Option 1 (defined as in the text box for FR1 in the beginning of this section of this document)**
* **Option 2 (defined as in the text box for FR1 in the beginning of this section of this document)**
* **Other option (please describe in the Comments field)**

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| --- | --- |
| **Company** | **Comments** |
| Template | Preferred: Option X  Acceptable: Option X, Y |
| Intel | Preferred: Option 2  Acceptable: Option 2.  Same reasons as for FR1. |

For Option 2, we have also the following FFS pertaining to BWP#0 configuration option 1:

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| * For a separate initial DL BWP (if it does not include CD-SSB and the entire CORESET#0),   + If it is configured for random access while not for paging in idle/inactive mode, RedCap UE does NOT expect it to contain SSB/CORESET#0/SIB.     - FFS: For BWP#0 configuration option 1, whether the UE can expect SSB transmission in the separate initial DL BWP when it is used in connected mode. |

A few contributions provided views on the above FFS. Two contributions [4, 26] indicate that UE should not expect SSB for BWP#0 configuration option 1, while two other contributions [15, 28] mention that UE expects SSB transmission in the separate initial DL BWP when it is used in connected mode:

* [4]: For BWP#0 configuration option 1, the use of initial DL BWP in connected mode is quite limited from both functionality and power saving perspectives.
* [4]: For BWP#0 configuration option 1, if the separate initial DL BWP is configured for random access but not for paging, then the UE does not expect SSB transmission in the separate initial DL BWP in RRC idle/inactive/connected states.
* [15]: For BWP#0 configuration option 1, UE expect SSB transmission in the separate initial DL BWP when it is used in connected mode.
* [26]: RAN1 agrees on the support of Option 2 by removing FFS for BWP#0 configuration option 1, meaning that BWP#1 with dedicated RRC configuration which includes SSB reception related configuration would be used in connected mode.
* [28]: For connected mode operation, if UE can expect SSB configured in an RRC configured active BWP then so should be the case in the initial DL BWP configured by configuration option 1, too.

**FL1 High Priority Question 5-3a: Please provide your view on the following FFS in Option 2:**

* **For a separate initial DL BWP (if it does not include CD-SSB and the entire CORESET#0),**
  + **If it is configured for random access while not for paging in idle/inactive mode, RedCap UE does NOT expect it to contain SSB/CORESET#0/SIB.**
    - **FFS: For BWP#0 configuration option 1, whether the UE can expect SSB transmission in the separate initial DL BWP when it is used in connected mode.**

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| **Company** | **Y/N** | **Comments** |
| Intel |  | For BWP#0 configuration option 1 is not expected have much practical relevance for RedCap use-cases. Thus, to avoid long discussions on this issue that is likely a rather corner case, we propose that **BWP #0 configuration option 1 is NOT supported for RedCap.** |
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# SI update mechanism

Another FFS identified in RAN1#106bis-e [2] concerns whether additional mechanism for SI update is needed and how SI update notifications and/or SI updates are signalled to RedCap UEs. Several contributions [4, 7, 8, 19, 24, 27, 29] discuss that in RRC connected state when the RedCap DL BWP does not contain the entire CORESET#0, RedCap UEs rely on dedicated SI delivery. Also, notification of SI update can be provided via paging DCI if the DL BWP contains the paging CSS [4, 30]. For SI update in RRC idle/inactive state when the RedCap initial DL BWP does not contain the entire CORESET#0, RedCap UEs rely on switching to CORESET#0 to acquire SI updates [4, 8, 15, 27, 30].

Based on the expressed views, the following proposal can be considered:

**Medium Priority Question 6-1a: What (if any) changes or clarifications are needed in order to support SI update for RedCap UEs in idle/inactive state?**

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| **Company** | **Comments** |
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**Medium Priority Question 6-2a: What (if any) changes or clarifications are needed in order to support SI update for RedCap UEs in connected state?**

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| **Company** | **Comments** |
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# FGs for BWP operation

RAN1#105-e [2] made the following agreement related to non-initial BWP operation:

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| Agreements: Take the following as an agreement, revised from the RAN1#104bis-e working assumption:   * A RedCap UE cannot be configured with a non-initial (DL or UL) BWP (i.e., a BWP with a non-zero index) wider than the maximum bandwidth of the RedCap UE.   + At least for FR1, FG 6-1 (“Basic BWP operation with restriction” as described in TR 38.822) is used as a starting point for the mandatory RedCap UE type capability.     - This does not preclude support of FG 6-1a (“BWP operation without restriction on BW of BWP(s)” as described in TR 38.822) as a UE capability for RedCap UEs. |

Several contributions provide their views on non-initial BWP operation and in particular FG 6-1a “BWP operation without restriction on BW of BWPs”. In some of the contributions, it is proposed to make FG 6-1a mandatory for RedCap [5, 10]. In some other contributions, it is proposed to have FG 6-1a as an optional feature for RedCap [24, 27]. Meanwhile, several contributions propose to have new or modified FGs for RedCap [4, 9, 11, 14, 19]:

* [4]: The RedCap UE should support a new FG for BWP operation where an RRC-configured DL BWP contains SSB but not CORESET#0.
* [9]: Define new capabilities like FG 6-1/6-1a/6-2/6-3/6-4 to consider SSB and CORESET of CSS presence in the UE-specific DL BWP.
* [11]: RedCap UE should support a modified FG 6-1a, in which CORESET#0 is removed from the original FG 6-1a.
* [14]: FGs 6-1 and 6-1a (at least FGs 6-1) should be adapted for RedCap UEs such that RedCap UEs mandatorily support operation in active DL BWPs that may not necessarily include CORESET#0.
* [19]: Introducing a new UE feature for RedCap to indicate whether it supports an active BWP configured with UE-specific search space (USS) without SSB, denoting as Feature-X.

This can be discussed further (possibly as part of the UE capability discussion) once the related issues discussed in other sections of this document have progressed a bit further.

# PUCCH transmission

Regarding PUCCH (for Msg4/[MsgB] HARQ feedback) transmissions during initial access, we have the following agreement and FFSs:

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| Agreement:   * FFS: What specification changes (if any) are needed to support that the network can enable/disable intra-slot PUCCH frequency hopping (FH) within the separate initial UL BWP in the PUCCH resource for HARQ feedback for Msg4/MsgB for RedCap * FFS: Whether any specification changes are needed and desired in order to support multiplexing of non-FH and FH PUCCH transmissions in PUCCH resources. |

**Disabling** **frequency hopping:**

The contributions generally agree that specification changes are required to support disabling the PUCCH FH in the PUCCH resource for HARQ feedback for Msg4/MsgB for RedCap [4, 5, 7, 8, 11, 15, 21, 23, 24, 26, 27, 29]. In particular, it needs to be specified which hop or PRB index is used for RedCap PUCCH resources when the FH is disabled. In this case, different solutions might be possible. Therefore, companies are invited to provide their comments on the specification changes needed for determining PRB indices to be used for PUCCH resources.

Based on the above views, the following question can be considered.

**FL1 High Priority Question 8-1a: Considering minimum specification changes, how should the PRB indices for RedCap PUCCH resources (for HARQ feedback for Msg4/MsgB) with disabled FH be determined?**

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| **Company** | **Comments** |
| Intel | The cell-common PUCCH resources are provided as part of separate PUCCH-ConfigCommon in the separate initial UL BWP for RedCap. For a PUCCH resource, the PRB indices can be determined as before – with the exception that, when FH is disabled, the location of the first hop is used for the entire PUCCH duration. With dynamic PRI and slot offset/starting symbol indications, the gNB would have sufficient degrees of freedom to indicate PUCCH resources for HARQ-Ack feedback from RedCap UEs while minimizing PUSCH resource fragmentation. |
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**PUCCH multiplexing:**

The contributions express different views on multiplexing of non-FH and FH PUCCH transmissions in PUCCH resources. The majority of the contributions indicate that the multiplexing can be done by a proper configuration and avoiding overlap between time-frequency resources (e.g., using different PRBs) of non-FH and FH PUCCH transmissions [4, 7, 8, 11, 14, 15, 17, 21, 23, 25, 28]. In addition, it is mentioned that such multiplexing problem for non-FH and FH PUCCH transmissions is not a new issue as it already exists for non-RedCap UEs in connected mode. Therefore, there might not be a need for any enhancements or specification changes in order to support multiplexing of non-FH and FH PUCCH transmissions in PUCCH resources. However, a few contributions [5, 19, 26] argue that two base sequences should be used for non-FH PUCCH transmissions to support multiplexing of non-FH and FH PUCCH transmissions in the same PRB.

**Medium Priority Question 8-2a: Are any specification changes necessary in order to support multiplexing of non-FH and FH PUCCH transmissions in PUCCH resources? If yes, please elaborate in the Comments field.**

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| **Company** | **Y/N** | **Comments** |
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# Other issues

In this section, companies are invited to bring up other issues relevant for the timely completion of the RAN1 part of the Rel-17 RedCap WI, if any.

**Medium Priority Question 9-1a: Companies are invited to bring up other issues relevant for the timely completion of the RAN1 part of the Rel-17 RedCap WI, if any.**

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| **Company** | **Comments** |
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# References

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| [1] | [RP-211574](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_92e/Docs/RP-211574.zip) | Revised WID on support of reduced capability NR devices | Ericsson |
| [2] | [R1-2110669](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2110669.zip) | RAN1 agreements for Rel-17 NR RedCap | Rapporteur (Ericsson) |
| [3] | [R1-2110381](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2110381.zip) | FL summary #5 on reduced maximum UE bandwidth for RedCap | Moderator (Ericsson) |
| [4] | [R1-2110769](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2110769.zip) | Reduced maximum UE bandwidth for RedCap | Ericsson |
| [5] | [R1-2110801](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2110801.zip) | Reduced maximum UE bandwidth | Huawei, HiSilicon |
| [6] | [R1-2110892](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2110892.zip) | Bandwidth Reduction for RedCap UEs | FUTUREWEI |
| [7] | [R1-2111019](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111019.zip) | Remaining issues on reduced maximum UE bandwidth | Vivo, Guangdong Genius |
| [8] | [R1-2111066](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111066.zip) | Bandwidth reduction for reduced capability NR devices | ZTE, Sanechips |
| [9] | [R1-2111101](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111101.zip) | Discussion on aspects related to reduced maximum UE bandwidth | Spreadtrum Communications |
| [10] | [R1-2111129](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111129.zip) | Bandwidth Reduction for Reduced Capability Devices | Nokia, Nokia Shanghai Bell |
| [11] | [R1-2111262](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111262.zip) | Discussion on reduced maximum UE bandwidth | CATT |
| [12] | [R1-2111322](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111322.zip) | Discussion on reduced UE bandwidth | OPPO |
| [13] | [R1-2111403](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111403.zip) | Discussion on reduced maximum UE bandwidth for RedCap | Sony |
| [14] | [R1-2111501](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111501.zip) | On reduced max UE BW for RedCap | Intel Corporation |
| [15] | [R1-2111578](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111578.zip) | Discussion on the remaining issues of reduced UE bandwidth for RedCap | Xiaomi |
| [16] | [R1-2111595](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111595.zip) | Discussion on aspects related to reduced maximum UE bandwidth | ASUSTeK |
| [17] | [R1-2111613](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111613.zip) | Discussion on reduced maximum UE bandwidth | CMCC |
| [18] | [R1-2111744](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111744.zip) | UE complexity reduction | Samsung |
| [19] | [R1-2111880](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111880.zip) | Reduced maximum UE bandwidth for RedCap | Apple |
| [20] | [R1-2111957](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111957.zip) | Discussion on BWP operation for RedCap | NEC |
| [21] | [R1-2111963](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111963.zip) | Discussion on reduced maximum bandwidth for RedCap UEs | InterDigital, Inc. |
| [22] | [R1-2112006](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2112006.zip) | Reduced maximum UE bandwidth for RedCap | Lenovo, Motorola Mobility |
| [23] | [R1-2112015](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2112015.zip) | Discussion on reduced maximum UE bandwidth | Sharp |
| [24] | [R1-2112056](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2112056.zip) | Aspects related to the reduced maximum UE bandwidth of RedCap | LG Electronics |
| [25] | [R1-2112084](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2112084.zip) | Aspects related to reduced maximum UE bandwidth for RedCap | Panasonic Corporation |
| [26] | [R1-2112113](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2112113.zip) | Discussion on reduced maximum UE bandwidth for RedCap | NTT DOCOMO, INC. |
| [27] | [R1-2112223](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2112223.zip) | BW Reduction for RedCap UE | Qualcomm Incorporated |
| [28] | [R1-2112283](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2112283.zip) | On reduced maximum bandwidth for RedCap UEs | MediaTek Inc. |
| [29] | [R1-2112376](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2112376.zip) | On aspects related to reduced maximum UE BW | Nordic Semiconductor ASA |
| [30] | [R1-2111132](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111132.zip) | On other aspects of RedCap | Nokia, Nokia Shanghai Bell |
| [31] | [R1-2111580](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111580.zip) | Discussion on the remaining issues of higher layer related topics for RedCap | Xiaomi |
| [32] | [R1-2111616](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111616.zip) | Discussion on other aspects of RedCap UE | CMCC |
| [33] | [R1-2111923](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111923.zip) | On RedCap UE RF retuning | Huawei, HiSilicon |
| [34] | [R1-2111966](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111966.zip) | Considerations for initial BWP for RedCap UEs | InterDigital, Inc. |
| [35] | [R1-2112007](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2112007.zip) | RAN1 aspects for RAN2-led features for RedCap | Lenovo, Motorola Mobility |
| [36] | [R1-2112225](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2112225.zip) | Cross Layer Design Considerations for RedCap Device | Qualcomm Incorporated |
| [37] | [R1-2110600](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2110600.zip) | LS on use of NCD-SSB instead of CD-SSB for RedCap UE | RAN1, Ericsson |