3GPP TSG-RAN WG1 Meeting #106-e R1-21xxxxx

e-Meeting, 16th – 27th August 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].

This document summarizes contributions [3] – [29] submitted to agenda item 8.6.1.1 and relevant parts of contributions [30] – [40] submitted to agenda item 8.6.3 and captures this email discussion on reduced maximum UE bandwidth:

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| [106-e-NR-R17-RedCap-01] Email discussion regarding aspects related to reduced maximum UE bandwidth – Johan (Ericsson)   * 1st check point: August 19 * 2nd check point: August 24 * Final check: August 27 |

The final FLS from the previous RAN1 meeting and the draft LS that was discussed then can be found in [41] and [42].

The issues in this document are tagged and color coded with High Priority or Medium Priority.

In this round of the email discussion, please comment on the issues tagged ‘FL1’ before Monday 16th August 22:00 UTC.

Follow the naming convention in this example:

* *RedCapBwFLS1-v000.docx*
* *RedCapBwFLS1-v001-CompanyA.docx*
* *RedCapBwFLS1-v002-CompanyA-CompanyB.docx*
* *RedCapBwFLS1-v003-CompanyB-CompanyC.docx*

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

* Assume CompanyC wants to update *RedCapBwFLS1-v002-CompanyA-CompanyB.docx*.
* CompanyC uploads an empty file named *RedCapBwFLS1-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 in Annex).
* CompanyC then has 30 minutes to upload *RedCapBwFLS1-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 [R1-2106403](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106403.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.

# Initial DL BWP

## Initial DL BWP during initial access

RAN1#104bis-e agreed the following working assumption related to initial DL BWP during initial access:

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| Working assumption:   * During initial access, the bandwidth of the initial DL BWP for RedCap UEs is not expected to exceed the maximum RedCap UE bandwidth.   + The bandwidth and location of the initial DL BWP for RedCap UEs can be the same as the bandwidth and location of the MIB-configured initial DL BWP for non-RedCap UEs.   + This does not preclude a SIB-configured initial DL BWP for non-RedCap UEs only with a wider bandwidth than the maximum RedCap UE bandwidth.   + This does not preclude separate or additional bandwidth and location for initial DL BWP for RedCap UEs (FFS). |

Regarding the initial DL BWP during initial access, contributions unanimously agree to confirm the working assumption indicating that, during initial access, the bandwidth of the initial DL BWP for RedCap UEs is not expected to exceed the maximum RedCap UE bandwidth [3, 4, 7, 9, 13, 15, 16, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29]. Moreover, most of these contributions indicate that a separate initial DL BWP (i.e., with separate/additional location and bandwidth) can be configured for RedCap UEs. One contribution [10] argues that there is no need to introduce a separate initial DL BWP for RedCap UEs during the initial access. Another contribution [12] mentions that a description of a separate DL BWP is needed before any agreements are made. Note that further clarifications and discussions regarding the separate initial DL BWP for RedCap are provided in Section 2.2 of this FL document.

**FL1 High Priority Proposal 2.1-1: Confirm the following RAN1#104bis-e working assumption with removed FFS from the third sub-bullet:**

* **During initial access, the bandwidth of the initial DL BWP for RedCap UEs is not expected to exceed the maximum RedCap UE bandwidth.**
  + **The bandwidth and location of the initial DL BWP for RedCap UEs can be the same as the bandwidth and location of the MIB-configured initial DL BWP for non-RedCap UEs.**
  + **This does not preclude a SIB-configured initial DL BWP for non-RedCap UEs only with a wider bandwidth than the maximum RedCap UE bandwidth.**
  + **This does not preclude separate or additional bandwidth and location for initial DL BWP for RedCap UEs ~~(FFS)~~.**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon | Y |  |
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## Separate initial DL BWP

RAN1#105-e agreed the following working assumption related to initial DL BWP during initial access:

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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 |

As described in several contributions (e.g., [4, 5, 6, 8, 9, 16]), configuring/defining a separate initial DL BWP for RedCap UEs can be beneficial for flexibility and offloading purposes. However, there are several FFSs identified in RAN1#105-e which need to be discussed. The FL proposes to confirm the main working assumption from RAN1#105-e regarding the separate initial DL BWP while keeping the FFSs which will be addressed in subsequent proposals.

**FL1 High Priority Proposal 2.2-1: Confirm the above working assumption from RAN1#105-e regarding the separate initial DL BWP while keeping the FFSs.**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon | Y |  |
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Next, the FFSs related to the separate initial DL BWP for RedCap are discussed.

**Details of the configuration/definition**

Most of the contributions indicate that the configuration for a separately configured initial DL BWP for RedCap UEs can be signaled in SIB [4, 5, 6, 18, 22, 23, 26, 28]. Also, several contributions mention that the separate initial DL BWP for RedCap UEs can include a configuration of CORESET and CSS(s) [4, 5, 6, 24, 29]. Meanwhile, the detailed signaling solution for the configuration of the RedCap initial BWP is up to RAN2 [4, 16].

**Medium Priority Proposal 2.2-2: The configuration for a separately configured initial DL BWP for RedCap UEs can be signaled in SIB.**

* **The separate initial DL BWP for RedCap UEs can include configuration of CORESET and CSS(s).**
* **Detailed signaling solution for configurations is up to RAN2.**

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| **Company** | **Y/N** | **Comments** |
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**Use of separate initial DL BWP during initial access**

If a separate initial DL BWP for RedCap UEs is configured/defined, the separate initial DL BWP for RedCap UEs can be used during initial access [4, 20, 24, 25, 29]. Contribution [4] states that for RedCap UEs, the IE *locationAndBandwidth* specified in the initial DL BWP can be applied and used during the initial access. One contribution [17] mentions that, during initial access, RedCap and non-RedCap UEs share the SSB, CORESET#0, SIB1 and initial DL BWP.

**FL1 High Priority Proposal 2.2-3: A separate initial DL BWP for RedCap UEs (if configured) can be used during the initial access.**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon | Clarification needed | Suggest the proposal is conditioned as “Can be used for aligning the DL and UL center frequency during initial access for unpaired spectrum.”  If not agreeable, we suggest to firstly proceed with discussion on the following issue for DL during initial access:   * Whether a RedCap UE can be assumed to be able to perform RF retuning (FFS by BWP switching/retuning/hopping) * As a baseline, without additional SSB, what needs to be supported if a RedCap UE is configured with an initial DL BWP without BW containing SSB |
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**Whether a separate SIB-configured initial DL BWP contains the entire CORESET #0**

Most contributions propose that a separate SIB-configured initial DL BWP does not need to contain the entire CORESET #0 [4, 5, 6, 8, 15, 18, 20, 23, 24, 29]. One contribution [16] thinks that a separately configured initial DL BWP for RedCap UEs needs to contain the entire CORESET #0.

**FL1 High Priority Proposal 2.2-4: A separate SIB-configured initial DL BWP for RedCap UEs does not need to contain the entire CORESET #0.**

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| **Contribution** | **Y/N** | **Comments** |
| Huawei, HiSilicon | Clarification needed | For unpaired spectrum during initial access, the separately SIB-configured DL BWP does not need to contain the entire CORESET#0 and any other CORESETs, i.e. the proposal does not imply the need of additional CORESET#0 for RedCap UEs. |
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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:

* [5]: The supported bandwidths in the separate initial DL BWP for RedCap UEs should take following factors into account: CSS types supported in the separate initial DL BWP, UE’s complexity for DCI size determination for fallback DCI formats, and NW’s configuration flexibility and efficiency for resource usage.
* [12]: If a separately initial BWP is supported, the possible bandwidths are among the bandwidths for CORESET#0 derived from the MIB.
* [16]: Reuse the existing setting for deriving *locationAndBandwidth* with constraints on the ranges of the values.

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 bandwidth. Since this topic are not discussed by many contributions and it will not affect the subsequent discussions, the FL suggests deprioritizing this topic.

**Medium Priority Proposal 2.2-5: The discussion on the supported bandwidths in the separate initial DL BWP for RedCap is not prioritized.**

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| **Company** | **Y/N** | **Comments** |
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**Whether to transmit additional SSB**

There are different views on whether an additional SSB is transmitted in the separate initial DL BWP for RedCap. Some contributions [3, 4, 6, 8, 9, 12] argue that transmission of additional SSBs in a separate initial DL BWP for RedCap may not be needed and can result in significant overhead and increased inter-cell interference. Some other contributions propose that additional SSB in the separate initial DL BWP should be transmitted [5, 11, 18, 22, 24, 26, 28].

* [4] discusses that whether the network configures an additional SSBs to be transmitted in the separate SIB-configured initial DL BWP for RedCap should be based on the SSB transmission periodicity and the DRX cycle.
* [18] mentions that additional SSB can be transmitted in the separate initial DL BWP for RedCap UEs with a periodicity larger than CD SSB to reduce the overhead of gNB.
* [19] discusses that Rel-15/16 supports configuration of additional SSB, which can also be used for RRM measurement by legacy UEs, and that optimization of SS-block for the purpose of RedCap UEs can be further studied.
* [21] argues that if SSB may need to be duplicated in a RedCap UE’s active DL BWP, some means to avoid a false detection of the duplicated SSB by other UEs as a cell-defining SSB will be needed.

**FL1 High Priority Proposal 2.2-6: Transmission of additional SSBs in the separate initial DL BWP for RedCap can be configured by the network.**

* **FFS: details of the configuration when additional SSBs are configured**
* **FFS: details of the configuration when additional SSBs are not configured**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon | N | We think using the same initial DL BWP for SSB reception and RF retuning of UEs as needed, is a simpler and more implementable solution. R15/R16 specifications also support RF retuning operations in e.g. BWP switching, SRS switching and Tx switching and they are commercially used for non-RedCap UEs already.  We do not see the need to additionally configure the additional SSBs which cause unnecessary overhead, increase complexity for network planning, and require more handling of both UE and gNB for collision. Additional SSB is rarely commercially used in practically networks as its drawbacks held above. |
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**Separate initial DL BWP in FDD case**

Several contributions support that an initial DL BWP for RedCap UEs can be optionally configured/defined separately from the initial DL BWP for non-RedCap UEs in FDD [6, 8, 9, 15, 16, 20, 21, 26, 27, 28, 29].

**Medium Priority Proposal 2.2-7: An initial DL BWP for RedCap UEs can be optionally configured/defined separately from the initial DL BWP for non-RedCap UEs in FDD.**

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| **Company** | **Y/N** | **Comments** |
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## Initial DL BWP after initial access

RAN1#105-e agreed the following working assumption related to initial DL BWP after initial access:

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| Agreements: Replace the RAN1#104bis-e working assumption with the following working assumption (for option 1) and working assumption (for option 2):   * Working assumption: After initial access (i.e., after RRC Setup, RRC Resume, or RRC Reestablishment), for BWP#0 configuration option 1 (as in 38.331, Appendix B2), a RedCap UE is not expected to operate with an initial DL BWP wider than the maximum RedCap UE bandwidth. * Working assumption: After initial access (i.e., after RRC Setup, RRC Resume, or RRC Reestablishment), for BWP#0 configuration option 2 (as in 38.331, Appendix B2), a RedCap UE is not expected to operate with an initial DL BWP wider than the maximum RedCap UE bandwidth. |

Regarding the initial DL BWP after initial access, the working assumptions state that a RedCap UE is not expected to operate with an initial DL BWP wider than the maximum RedCap UE bandwidth for BWP#0 configuration option 1 and option 2. Most of the contributions [4, 5, 6, 7, 8, 12, 13, 15, 17, 18, 19, 20, 22] agree to confirm these working assumptions.

**FL1 High Priority Proposal 2.3-1: Confirm the following working assumptions from RAN1#105-e:**

* **After initial access (i.e., after RRC Setup, RRC Resume, or RRC Reestablishment), for BWP#0 configuration option 1 (as in 38.331, Appendix B2), a RedCap UE is not expected to operate with an initial DL BWP wider than the maximum RedCap UE bandwidth.**
* **After initial access (i.e., after RRC Setup, RRC Resume, or RRC Reestablishment), for BWP#0 configuration option 2 (as in 38.331, Appendix B2), a RedCap UE is not expected to operate with an initial DL BWP wider than the maximum RedCap UE bandwidth.**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon | Y |  |
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# Initial UL BWP

## General

RAN1#105-e made the following agreements related to initial UL BWP:

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| Agreements:   * Both during and after initial access, the scenario where the initial UL BWP for non-RedCap UEs is configured to be wider than the maximum RedCap UE bandwidth is allowed. * Working assumption: Both during and after initial access, for the scenario where the initial UL BWP for non-RedCap UEs is configured to be wider than the RedCap UE bandwidth, a separate initial UL BWP no wider than the RedCap UE maximum bandwidth is configured/defined for RedCap UEs.   + FFS: whether/how to avoid or minimize PUSCH resource fragmentation due to PUCCH transmission for the above case   + Support the case when the centre frequency is assumed to be the same for the initial DL and UL BWPs in TDD.     - FFS whether or not to additionally support the case when the centre frequency is different; if so, how to minimize centre frequency retuning   Working assumption:   * Both during and after initial access, even for the scenario where the initial UL BWP for non-RedCap UEs is not configured to be wider than the RedCap UE bandwidth, a separate initial UL BWP can optionally be configured/defined for RedCap UEs. * RO sharing between RedCap and non-RedCap is not precluded. |

Regarding the initial UL BWP configuration during and after initial access, many contributions agree with the main bullets of the working assumptions (while keeping the FFSs) presented in RAN1#105-e [4, 12, 13, 14, 18, 19, 22, 26, 27]. One contribution [12] points out that the relationship between both working assumptions regarding separate initial UL BWP for RedCap UEs and RO sharing between RedCap and non-RedCap UEs must be clarified. Regarding RO sharing, the FL’s understanding is that ROs can be fully or partially shared between RedCap and non-RedCap UEs. Companies are encouraged to provide necessary clarifications if needed.

**FL1 High Priority Proposal 3.1-1: Confirm the following working assumption from RAN1#105-e:**

* **Both during and after initial access, for the scenario where the initial UL BWP for non-RedCap UEs is configured to be wider than the RedCap UE bandwidth, a separate initial UL BWP no wider than the RedCap UE maximum bandwidth is configured/defined for RedCap UEs.**
  + **FFS: whether/how to avoid or minimize PUSCH resource fragmentation due to PUCCH transmission for the above case**
  + **Support the case when the centre frequency is assumed to be the same for the initial DL and UL BWPs in TDD.** 
    - **FFS whether or not to additionally support the case when the centre frequency is different; if so, how to minimize centre frequency retuning**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon | Y although | We think it is more urgent to resolve the FFS. |
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**Medium Priority Proposal 3.1-4: Confirm the following working assumption from RAN1#105-e:**

* **Both during and after initial access, even for the scenario where the initial UL BWP for non-RedCap UEs is not configured to be wider than the RedCap UE bandwidth, a separate initial UL BWP can optionally be configured/defined for RedCap UEs.**
  + **RO sharing between RedCap and non-RedCap is not precluded.**

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| **Company** | **Y/N** | **Comments** |
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There are two FFSs pertaining to configuring a separate initial UL BWP for RedCap UEs:

**Avoiding or minimizing PUSCH resource fragmentation**

One issue with separate initial UL BWP for RedCap and non-RedCap UEs is the potential PUSCH resource fragmentation due PUCCH transmissions. According to the WID, coexistence with non-RedCap UEs needs to be ensured. Therefore, while supporting RedCap UEs, it is essential to minimize the impact on non-RedCap UEs.

Several contributions discuss that the potential PUSCH resource fragmentation can be minimized by placing the RedCap initial UL BWP at one edge of the carrier and/or disabling the PUCCH frequency hopping [3, 4, 8, 10, 17, 18, 22, 23, 24, 25]. In particular, the network should be allowed to disable the PUCCH frequency hopping for RedCap UEs during initial access (for Msg4/[MsgB] HARQ feedback) [4, 8, 10, 18, 21, 22, 23, 24, 25].

Some other views expressed in the contributions:

* [4]: Without enhancing the existing BWP or PUCCH solutions, PUSCH resource fragmentation due to PUCCH transmissions from RedCap UEs may result in a significant reduction in UL peak user data rate KPI.
* [12]: Disabling of frequency hopping can be further investigated.
* [17]: UL resource fragmentation is a pre-existing issue for Rel-15/16 non-RedCap UEs. To support features and use cases introduced in NR Rel-16/17 (e.g., 2-step RACH, power saving, RedCap UE, coverage enhancement and SDT), it is desirable for NW to adopt a scalable and forward-compatible solution based on early indication of UE types/capabilities and adaptive resource configuration for PUCCH/PUSCH.
* [28]: Specification changes to avoid/minimize PUSCH fragmentation are not required.

**FL1 High Priority Proposal 3.1-2****: It is supported that the network can enable/disable PUCCH frequency hopping for HARQ feedback for Msg4/MsgB for RedCap UEs.**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon | Partially | It would be good to clearly use intra- or inter-slot PUCCH frequency hopping in proposals |
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**Initial UL/DL BWP center frequency in TDD**

Another key consideration is related to initial UL/DL BWP center frequency in TDD. Several contributions support having the possibility of separate center frequencies for initial UL/DL BWPs in TDD [4, 6, 8, 9, 10, 25, 27, 28]. In addition, [8] states that in case of different center frequencies, center frequency retuning can be minimized by optimized gNB configuration. However, some other contributions indicate that the same center frequency should be maintain for initial UL/DL BWP [5, 17, 18, 22, 26]. However, in this case, the initial DL BWP located at the edge may not contain CORESET #0 [4, 8, 20, 24, 29]. Based on the above discussions, the following can be considered.

**FL1 High Priority Question 3.1-3: Regarding the initial UL/DL BWPs center frequency in TDD, should the following options be considered for down selection? If so, please indicate your preferred option.**

* **Option 1: The center frequencies for initial UL/DL BWPs can be different, and the initial DL BWP contains the entire CORESET #0.**
* **Option 2: The center frequencies for initial UL/DL BWPs are the same, and the initial DL BWP does not necessarily contain CORESET #0.**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon | Opt2 | As previously stated, the separately configured initial DL BWP does not need to contain any CORESETs including CORESET#0 - it is only for keeping the center frequency of UL and DL at UE side, such that no real overhead increment (due to additional CORESETs) to network and no change to UE implementation. There is no urgent need to take option 1 during initial access since the Tx-Rx is naturally TDMed such that UE has sufficient time for performing RF retuning. |
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## RACH occasions

RAN1#105-e made the following working assumption related RACH occasions:

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| Working assumption:   * For enabling/supporting that the RACH occasion (RO) associated with the best SSB falls within the RedCap UE bandwidth, support separate initial UL BWP for RedCap UEs (which is not expected to exceed the maximum RedCap UE bandwidth), and this separate initial UL BWP for RedCap includes ROs for RedCap UEs.   + Note: these ROs can be dedicated for RedCap UEs or shared with non-RedCap UEs. |

Many contributions agree to confirm the working assumption from RAN1#105-e related to RACH occasions [4, 6, 7, 13, 18, 19, 20, 26]. Contribution [4] discusses that it is desired to share RACH resources are shared between RedCap and non-RedCap UEs. However, [12] states that before any agreements, the relationship between both working assumptions regarding separate initial UL BWP for RedCap UEs and RO sharing between RedCap and non-RedCap UEs must be clarified. Regarding RO sharing, the FL’s understanding is that ROs can be fully or partially shared between RedCap and non-RedCap UEs. Companies are encouraged to provide necessary clarifications if needed.

Some other views on ROs expressed in the contributions:

* [6]: In case of separate initial UL BWP for RedCap UEs, a separate mapping between ROs and SSBs may be needed when the ROs are shared with non-RedCap UEs.
* [10]: When the ROs are shared by RedCap UE and normal UE, and if the set of ROs still exceed the maximum RedCap UE bandwidth,
  + The gNB can configure more than one RedCap-dedicated initial UL BWP candidates to cover all the ROs.
  + A RedCap UE should apply one of the candidates as its initial UL BWP based on its selected RO.

**FL1 High Priority Proposal 3.2-1: Confirm the above working assumption from RAN1#105-e regarding RACH occasions.**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon | N | In our understanding, only when the initial UL BWP can have multiple frequency locations, the RO issue can be resolved. We suggest not to confirm the WA and to proceed how the separate initial UL BWP include ROs spanning BW larger than the RedCap UE bandwidth such that the best SSB is supported/selective. |
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## PUCCH/PUSCH during initial access

RAN1#105-e made the following working assumption related to PUCCH/PUSCH during initial access:

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| Working assumption:   * For enabling/supporting that PUCCH (for Msg4/[MsgB] HARQ feedback) and/or PUSCH (for Msg3/[MsgA]) transmissions fall within the RedCap UE bandwidth during initial access, support separate initial UL BWP for RedCap UEs (which is not expected to exceed the maximum RedCap UE bandwidth).   + FFS: whether/how the specification also supports separate PUCCH/Msg3/[MsgA] PUSCH configuration/indication or a different interpretation of the same configuration/indication for RedCap (e.g., disabled frequency hopping or different frequency hopping) |

Regarding the working assumption from RAN1#105-e related to PUCCH/PUSCH during initial access, contributions generally agree that a separate initial UL BWP can be configured for RedCap to ensure that PUCCH/PUSCH transmissions during initial access fall within the UE bandwidth. Regarding the FFS for a separate PUCCH/Msg3/[MsgA] PUSCH configuration/indication, several contributions [3, 4, 8, 10, 18, 21, 22, 23, 25, 24] indicate that the specifications should support the possibility of disabling the PUCCH frequency hopping during the initial access for RedCap UEs. Two contributions [10, 12] propose to have an FFS for PUCCH frequency hopping. Also, two other contributions [18, 20] do not support having a separate PUCCH/Msg3/[MsgA] PUSCH configuration/indication. It should be noted that this working assumption is related to the discussions on minimizing PUSCH resource fragmentation provided in Section 3.1. There are several contributions supporting the possibility of disabling the PUCCH frequency hopping during initial access for RedCap UEs which may require a different configuration/indication/interpretation for PUCCH (for Msg4/[MsgB] HARQ feedback).

Some other views expressed in the contributions:

* [10]: FFS the frequency hopping of RedCap PUCCH in the initial UL BWP can be disabled.
* [10]: FFS the gNB shall always ensure that the location of the RedCap PUCCH resource set is included in the RedCap-dedicated initial UL BWP.
* [12]: FFS for disabling frequency hopping can be further investigated
* [18]: The specification doesn’t support separate PUCCH/Msg3/[MsgA] PUSCH configuration/indication or a different interpretation of the same configuration/indication for RedCap.
* [20]: Confirm the following W.A. (For enabling/supporting that PUCCH) with removing the option of disabled frequency hopping.

**FL1 High Priority Proposal 3.3-1: Confirm the above working assumption from RAN1#105-e regarding PUCCH/PUSCH during initial access.**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon | N | Similar comment - the unresolved FFS does not make the WA workable. Suggest to further discuss how specification supports separate UL configurations/indication associated with the same initial UL BWP. |
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# Non-initial BWP

RAN1#105-e 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 [3, 4, 6]. In addition, contributions discuss several benefits and aspects related o FG 6-1a:

* [3]: This feature does not have any additional requirement on UE hardware; thus, it will not increase RedCap UE cost/complexity.
* [4]: Support of FG 6-1a is beneficial for minimizing PUSCH resource fragmentation, and it allows supporting all SSB/CORESET #0 configurations.
* [4]: Without supporting FG 6-1a in TDD, the UE must support having different center frequencies for non-initial UL/DL BWPs.
* [29]: Non-initial DL BWP for RedCap UE with FG 6-1a BWP operation without restriction may improve frequency diversity gain for RedCap UE.

One contribution [21] discusses two interpretations of FG6-1a which can be considered for RedCap and suggests having an FFS:

* FG 6-1aa:
  + BW of UE-specific RRC configured BWP may not include BW of the CORESET#0 or SSB, but the active DL BWP and both of SSB and CORESET #0 are contained within the max RedCap UE BW.
  + This would be equivalent to FG 6-1a of Rel-15 for non-RedCap UEs.
  + FFS: Mandatory or optional for RedCap UEs
* FG 6-1ab:
  + BW of UE-specific RRC configured BWP may not include BW of the CORESET#0 or SSB, and the active DL BWP and one or both of SSB and CORESET #0 may span a BW that exceeds the max RedCap UE BW.
  + This implies need for RF retuning to receive SSB and/or CORESET #0 outside of active DL BWP. Further, measurement gaps may need to be defined for SSB reception and/or SI acquisition if active DL BWP does not include SSB and/or CORESET #0.
  + FFS: whether RedCap UEs support FG 6-1ab in FR1.

Meanwhile, one contribution [19] suggests discussing whether the RedCap UE may assume the bandwidth of the CORESET#0 and SSB does not exceed the maximum RedCap UE bandwidth so that FG 6-1a will not be needed.

**FL1 High Priority Question 4-1: Should RedCap UEs support FG 6-1a as a mandatory feature with the following clarification?**

* **BW of UE-specific RRC configured BWP may not include BW of the CORESET#0 or SSB.**
* **The active DL BWP and one or both of SSB and CORESET #0 may span a BW that exceeds the max RedCap UE BW.**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon | Almost | The current FG 6-1a concerns UE-specific RRC configured BWP for data reception. If we can assume that for unpaired spectrum, the initial DL BWP is only used for center frequency alignment between UL and DL then the implementation can be easier for UE – i.e., the **BW of ~~UE-specific RRC~~ separately configured initial DL BWP may not include BW of the CORESET#0 or SSB.**  This can be a dedicated FG for RedCap UE (due to RedCap specific issue), if companies concern taking FG6-1a as mandatory. |
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A few contributions indicate that if FG 6-1a is supported, additional features might need to be also supported. [11] mentions synchronization based purely on TRS and RSRP/RSRQ measurements of serving cell based on CSI-RS (FG1-5a). [17] refers to periodic TRS and dedicated RRC signaling for SI update.

* [11]: A RedCap UE not having SSB in active BWP would need to support at least optional features:
  + FG 6-1a including at least synchronization based purely on TRS,
  + RSRP/RSRQ measurements of serving cell based on CSI-RS (FG1-5a).
* [17]: If RedCap UE supports FG 6-1a and operates in an active DL BWP without CORESET0 or SSB, it expects to receive:
  + Periodic TRS for time/frequency tracking
  + Dedicated RRC signaling for SI update
  + Dedicated BFR-CSIRS-RACH resource, if BFR-CSI-RS is configured in the active BWP

**FL1 High Priority Question 4-2: Is there a need to support any other features or signaling related to non-initial BWP operation beyond FG 6-1a?**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon |  | As previously mentioned, the first reason for RedCap UEs to support a BWP BW without containing SSB can be for center frequency alignment purpose. In that case, a new FG similar as the current FG6-1a can be defined as mandatory. For other purpose, e.g. measurements, the legacy FG6-1a can remain and a measurement gap could be also configured for SS block based RRM measurement - i.e. other related features are not necessarily coupled. But we could be open for further discussion. |
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# RF retuning and BWP switching

Topics related to switching/hopping/retuning related to BWP operation has been discussed in contributions and during recent on-line meetings. Part of this discussion primarily is related to retuning timing, treated handled in Section 5.1 below, whereas more general aspects are treated in Section 5.2.

## RF switching delay

In the previous meeting, RAN1#105-e, no consensus could be reached regarding whether an LS should be sent to RAN4 for their input on RF switching time. The discussion was captured in [41] and a draft LS with the following LS text was provided in [42]. This LS text is included below for the reader’s convenience, with numbered paragraphs and sub-bullets added in red to facilitate further discussion. During the email discussion in RAN1#105-e, some contributions supported sending the LS, some contributions agreed to send only the first paragraph, one contribution wanted to make distinction between FR1 and FR2, and others opposed sending any LS on this topic.

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| Overall description 1) RAN1 has discussed the RedCap WI objective on “Reduced maximum UE bandwidth”. It is RAN1’s understanding that the existing Rel-15/16 BWP switching framework and related requirements can be reused for RedCap UEs, e.g., that the UE supports two BWPs and the centre frequency changes among the two BWPs. RAN1 would like RAN4 to confirm whether it is feasible to maintain the same BWP switching delays for RedCap UEs as currently specified for non-RedCap UEs.  2) Furthermore, RAN1 would like to ask RAN4 whether the switching delay for FR1 and FR2 could be reduced under the following assumptions (either as a mandatory or an optional UE capability):   1. The RF switching takes place between two frequency locations with different centre frequencies.    * Including cases such that the UL/DL centre frequencies are different in a TDD scenario    * Including cases such that the UE may assume the locations are selected from fewer number of candidates but not any raster currently required 2. The maximum UE RF bandwidth is 20 MHz for FR1 and 100 MHz for FR2.    * The frequency change is up to 80 MHz for FR1 and up to 300 MHz for FR2.    * Are there any switching ranges that could be faster compared to some other switching ranges? If any, please state the frequency ranges for both FR1 and FR2. 3. The RF bandwidth, SCS, QCL, and RRC configuration for the corresponding BWP can be the same before and after the RF switching, i.e. it is only the centre frequency that changes. 4. The RF switching may take place during initial access or after initial access. 5. The RF switching is either triggered by DCI or preconfigured and not triggered by DCI.   Other assumptions/cases can be fed back based on RAN4 discussion.  Note: The above does not imply that there is RAN1 consensus on related RF switching techniques. Actions **To RAN4:**  **ACTION:** RAN1 respectfully asks RAN4 to provide feedback on the question above on RF switching time. |

Several contributions continue to propose sending an LS to RAN4 for providing input related to the RF switching time, with at least some of the items above included [3, 9, 13, 21]. One contribution [17] proposes to consider reduced switching time for FR2, based on RAN4 input, but not for FR1. Other contributions suggest not to introduce reduced retuning delays for RedCap [5, 6, 8, 15, 19], some of which propose to send an LS to RAN4 seeking confirmation to reuse of existing framework and/or timing. Others continue to explicitly object to sending an LS [7].

Contribution [3] proposes to discuss, in UE feature session, whether any modified guard period time for RF retuning can also be used by non-RedCap UEs.

Contribution [17] proposes that for DCI based switching, RedCap UE should support Type-2 switching delay capability as a baseline.

**Medium Priority Question 5.1-1: Please indicate whether an LS shall be sent to RAN4, and if so, what paragraphs (1) and (2), and sub-bullets (a) to (e) can be included in the LS. Feel free to provide modified formulations and/or added sub-bullets if they may help progress the topic.**

**Given the difficulty in reaching a consensus in the previous meeting, companies might need to consider changing some positions, for the sake of progress. Note that sending an LS does not imply that there is RAN1 consensus on related RF switching techniques.**

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| **Company** | **Y/N** | **Comments** |
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## Other aspects of BWP switching and retuning

Many aspects related to BWP switching for UL and/or DL BWPs, as well as for initial and/or non-initial BWPs are already accounted for in the previous sections. For example, issues related to initial UL/DL BWP center frequency in TDD are addressed in Section 3.1, issues related to SSB potentially not being transmitted in initial/non-initial BWP for RedCap are treated in Sections 2.2 and 4. Some aspects specifically relevant for the BWP switching and/or retuning are listed below.

**BWP switching during initial access**

As noted in Section 3.1, several contributions support having different center frequencies for initial UL/DL BWPs, whereas other contributions oppose this. For the case when different center frequencies are supported, some contributions [4, 29] argue that the UL/DL timing can be configured such that enough time can be guaranteed to accommodate the UL/DL switch, and that this may need to be guaranteed by the standard. Though this is somewhat related to the discussion on RF switching delay in Section 5.1, the two issues can be discussed separately from each other, i.e., without suggesting any reduced switching time to address this scenario.

**Medium Priority Question 5.2-1: If a scenario with different center frequencies for initial UL/DL BWPs is supported in TDD, can the current specification and configuration options be used to guarantee that a UE is allowed enough time to perform the switching between UL and DL BWPs for a RedCap UE? If not, what specification changes are needed?**

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| **Company** | **Y/N** | **Comments** |
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**RF switching due to receiving SSB or monitoring CORESET#0**

This issue is related to the discussions in Sections 2.2 and 4 on whether a separate SIB-configured initial DL BWP contains the entire CORESET #0 and/or SSB.

Different views on support for switching to receive SSB (e.g., for RRM measurements) or monitoring CORESET#0 have been proposed. Some contributions propose introducing measurement gaps [6, 17, 19, 21, 22]. Other contributions mention that sufficient time gap shall be ensured [12], relaxations on UE transmission/reception requirements in connection with CORESET#0 monitoring and measurements [4], or in general that the infrequent switches shall be studied [20]. Contribution [3] suggests that this type of retuning shall be accomplished with efficient RF retuning, related to the reduced switching times in Section 5.1.

**Medium Priority Question 5.2-2: In a scenario where SSB and CORESET#0 is not transmitted within the UE BW, companies are encouraged to provide their views on how to accommodate SSB reception (e.g., for RRM measurements) and CORESET#0 monitoring with respect to, e.g., timing and mechanisms for the required retuning.**

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**Other**

Several contributions discuss BWP hopping/retuning/switching, but these aspects are mostly already handled in the discussion in Section 5.1 above related to the potential LS sent to RAN4, especially hopping (etc.) under conditions listed in sub-bullets (a) to (e). Other contributions argue that the current switching mechanisms are sufficient.

Contribution [26] suggests optimizing BWP framework to achieve frequency diversity.

Contribution [17] suggests introducing “virtual narrow BWP hopping” as well as a new mechanism for transitioning a UE to a narrow BWP after initial access, where the switching mechanism may be implicit or initiated/requested by the UE. However, these are proposed only for FR2.

# Other aspects

**SRS and CSI measurements:**

In [20], it is suggested to consider supporting SRS transmissions or CSI measurement/report for link adaptation outside active BWP. Also, sub-band CSI reporting is suggested as a means of reflecting the reduced RedCap UE bandwidth.

# Annex: Companies’ point of contact

**FL1 Question: 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** |
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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] | [R1-2106213](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2106213.zip) | RAN1 agreements for Rel-17 NR RedCap | Rapporteur (Ericsson) |
| [3] | [R1-2106459](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106459.zip) | Reduced maximum UE bandwidth | Huawei, HiSilicon |
| [4] | [R1-2106563](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106563.zip) | Reduced maximum UE bandwidth for RedCap | Ericsson |
| [5] | [R1-2106601](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106601.zip) | Discussion on reduced maximum UE bandwidth | vivo, Guangdong Genius |
| [6] | [R1-2106648](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106648.zip) | UE Complexity Reduction aspects related to reduced maximum UE bandwidth | Nokia, Nokia Shanghai Bell |
| [7] | [R1-2106705](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106705.zip) | Discussion on aspects related to reduced maximum UE bandwidth | Spreadtrum Communications |
| [8] | [R1-2106841](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106841.zip) | Bandwidth reduction for reduced capability NR devices | ZTE, Sanechips |
| [9] | [R1-2106894](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106894.zip) | UE complexity reduction | Samsung |
| [10] | [R1-2106977](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106977.zip) | Discussion on reduced maximum UE bandwidth | CATT |
| [11] | [R1-2107040](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107040.zip) | On aspects related to reduced maximum UE BW | Nordic Semiconductor ASA |
| [12] | [R1-2107089](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107089.zip) | Discussion on Bandwidth Reduction for RedCap UEs | FUTUREWEI |
| [13] | [R1-2107128](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107128.zip) | Discussion on reduced maximum UE bandwidth for RedCap | China Telecom |
| [14] | [R1-2107197](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107197.zip) | Discussion on reduced maximum UE bandwidth | TCL Communication Ltd. |
| [15] | [R1-2107249](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107249.zip) | Discussion on reduced UE bandwidth | OPPO |
| [16] | [R1-2107300](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107300.zip) | Discussion on aspects related to reduced maximum UE bandwidth | NEC |
| [17] | [R1-2107351](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107351.zip) | BW Reduction for RedCap UE | Qualcomm Incorporated |
| [18] | [R1-2107408](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107408.zip) | Discussion on reduced maximum UE bandwidth | CMCC |
| [19] | [R1-2107448](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107448.zip) | Aspects related to the reduced maximum UE bandwidth of RedCap | LG Electronics |
| [20] | [R1-2107496](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107496.zip) | On reduced maximum bandwidth for RedCap UEs | MediaTek Inc. |
| [21] | [R1-2107596](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107596.zip) | On reduced BW support for RedCap | Intel Corporation |
| [22] | [R1-2107745](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107745.zip) | Reduced maximum UE bandwidth for Redcap | Apple |
| [23] | [R1-2107794](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107794.zip) | Discussion on reduced maximum UE bandwidth | Sharp |
| [24] | [R1-2107809](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107809.zip) | Reduced maximum bandwidth for RedCap UEs | InterDigital, Inc. |
| [25] | [R1-2107864](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107864.zip) | Discussion on reduced maximum UE bandwidth for RedCap | NTT DOCOMO, INC. |
| [26] | [R1-2107926](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107926.zip) | Discussion on the remaining issues of reduced maximum UE bandwidth for RedCap | Xiaomi |
| [27] | [R1-2107947](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107947.zip) | Reduced maximum UE bandwidth for RedCap | Lenovo, Motorola Mobility |
| [28] | [R1-2108041](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108041.zip) | Aspects related to reduced maximum UE bandwidth | Panasonic Corporation |
| [29] | [R1-2108060](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108060.zip) | Discussion on aspects related to reduced maximum UE bandwidth | ASUSTeK |
| [30] | [R1-2106568](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106568.zip) | Potential RedCap solutions for avoiding or minimizing PUSCH resource fragmentation | Ericsson |
| [31] | [R1-2106605](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106605.zip) | Discussion on L1 reduced capability signaling | vivo, Guangdong Genius |
| [32] | [R1-2106653](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106653.zip) | Discussion on RedCap UE capabilities | Nokia, Nokia Shanghai Bell |
| [33] | [R1-2106846](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106846.zip) | NR UE features for RedCap | ZTE, Sanechips |
| [34] | [R1-2106982](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106982.zip) | Views on remaining issues of RedCap | CATT |
| [35] | [R1-2107385](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107385.zip) | Discussion on scaling factor for RedCap | Spreadtrum Communications, Apple, CEPRI |
| [36] | [R1-2107413](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107413.zip) | Discussion other aspects of RedCap UE | CMCC |
| [37] | [R1-2107452](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107452.zip) | Discussion on other aspects of RedCap | LG Electronics |
| [38] | [R1-2107669](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107669.zip) | On RedCap UL transmission | Huawei, HiSilicon |
| [39] | [R1-2107931](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107931.zip) | Discussion on the transmission of system information for RedCap | Xiaomi |
| [40] | [R1-2108050](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108050.zip) | Considerations on 2-step RACH for RedCap | Lenovo, Motorola Mobility |
| [41] | [R1-2106002](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2106002.zip) | FL summary #4 on reduced maximum UE bandwidth for RedCap | Moderator (Ericsson) |
| [42] | [R1-2106187](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2106187.zip) | [Draft] LS on RF switching time for RedCap UE | Ericsson |