3GPP TSG-RAN WG1 Meeting #104-e Tdoc R1-21xxxxx

e-Meeting, January 25th – February 5th, 2021

**Agenda Item: 8.6.1**

**Title: FL summary #4 for UE complexity reduction for RedCap**

**Source: Moderator (Ericsson)**

**Document for: Discussion, Decision**

# Introduction

This document summarizes contributions [1] – [28] and captures the following email discussion for the RedCap WI [29].

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| [104-e-NR-RedCap-01] Email discussion on UE complexity reduction – Johan (Ericsson)   * 1st check point: Jan 28 * 2nd check point: Feb 2 * 3rd check point: Feb 4 |

The issues in this document are tagged and color coded like this:

1. High Priority
2. Medium Priority
3. Low Priority

The previous rounds of this discussion were documented in FL summaries in [R1-2101849](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101849.zip), [R1-2101850](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101850.zip) and [R1-2101851](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101851.zip).

In this round of the discussion, companies are requested to provide comments before Thursday 4th February 19:00 UTC on the proposals and questions tagged FL9.

Follow the naming convention in this example:

* *RedCapFLS4-v000.docx*
* *RedCapFLS4-v001-CompanyA.docx*
* *RedCapFLS4-v002-CompanyA-CompanyB.docx*
* *RedCapFLS4-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 *RedCapFLS4-v002-CompanyA-CompanyB.docx*.
* CompanyC uploads an empty file named *RedCapFLS4-v003-CompanyB-CompanyC.checkout*
* CompanyC then has 30 minutes to upload *RedCapFLS4-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 underline character) and include ‘v’ in front of the version number, in line with the general recommendation (see slide 10 in [R1-2101668](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101668.zip)).

# Reduced maximum UE bandwidths

According to Rel-15/16 NR specifications, a UE is required to support 100 MHz in FR1 and 200 MHz in FR2.

The WID [29] has the following objective on reduced maximum UE bandwidths:

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| * Reduced maximum UE bandwidth:   + Maximum bandwidth of an FR1 RedCap UE during and after initial access of 20 MHz is supported. The possibility of, and any associated conditions for, optional support of a wider bandwidth up to 40 MHz after initial access for this case will be further discussed at RAN#91e.   + Maximum bandwidth of an FR2 RedCap UE during and after initial access is 100 MHz |

Based on the proposals in FL summary #1 in [R1-2101849](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101849.zip), the following RAN1 agreements were made in an online (GTW) session on Thursday 28th January:

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| Agreements:   * Sharing of the same SSB and CORESET#0 between RedCap and non-RedCap UEs is supported when the bandwidth is no wider than the RedCap UE bandwidth * The initial DL BWP (derived based on MIB/SIB) for RedCap UEs can be the same as the initial DL BWP for non-RedCap UEs at least when the initial DL BWP is no wider than the RedCap UE bandwidth.   + FFS: after initial access, whether a RedCap UE is allowed to operate with an initial DL BWP wider than the maximum RedCap UE bandwidth     - Discuss further whether or not it is also applicable during initial access * The initial UL BWP (derived based on SIB) for RedCap UEs can be the same as the initial UL BWP for non-RedCap UEs at least when the initial UL BWP is no wider than the RedCap UE bandwidth.   + FFS: during and after initial access, whether a RedCap UE is allowed to operate with an initial UL BWP wider than the maximum RedCap UE bandwidth * FFS whether or not to further introduce the following (e.g., for offloading purpose, for differentiation of RedCap vs. non RedCap UEs, for different BWP#0 configuration options, etc.) * Whether an additional CORESET can be configured for scheduling of RACH (msg2 & msg4)/Paging/SI messages for RedCap UEs * Whether the SIB-configured initial DL BWP for RedCap UEs can also be configured to be different from the SIB-configured initial DL BWP for non-RedCap UEs. * Whether the SIB-configured initial UL BWP for RedCap UEs can also be configured to be different from the SIB-configured initial UL BWP for non-RedCap UEs. |

## SSB and CORESET#0

Based on the proposals in FL summary #2 in [R1-2101850](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101850.zip), the following RAN1 conclusion was made in an online (GTW) session on Monday 1st February:

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| **Conclusion:** RAN1 does not consider acquisition time improvements for FR2 RedCap UEs with SSB and CORESET#0 multiplexing patterns 2 and 3 as part of this WI. |

## Initial BWPs

In principle, the initial BWP may be configured to span up to the entire carrier bandwidth. In the coexistence of RedCap UEs with legacy NR UEs, two general directions can be considered: 1) shared initial BWPs, and 2) separate initial BWPs.

Several contributions [1, 4, 18, 20, 24, 26] support having shared initial BWPs for RedCap and legacy UEs while other contributions [3, 6, 7, 8, 11, 23, 24] mention that having separate initial BWPs can be desirable or more feasible. In case of shared initial BWPs that exceed the UE BW, there might be a couple of issues that need to be discussed.

**RACH occasions outside the UE bandwidth**

Based on the proposals in FL summary #2 in [R1-2101850](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101850.zip), the following RAN1 agreements were made in an online (GTW) session on Monday 1st February:

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| --- |
| Agreements:   * Study further how to enable/support that a RACH occasion associated with the best SSB falls within the RedCap UE bandwidth, with the following options:   + Option 1: Proper RF-retuning for RedCap   + Option 2: Separate initial UL BWP(s) for RedCap UEs   + Option 3: gNB configuration (e.g., restrictions on existing PRACH configurations, or FDM-ed ROs, or always restricting the initial UL BWP to within RedCap UE bandwidth)   + Option 4: Dedicated PRACH configurations (e.g., ROs) for RedCap UEs   + Other options are not precluded |

**PUCCH/PUSCH frequency hopping outside the UE bandwidth**

Another potential issue in a shared initial UL BWP is related to the frequency hopping for PUCCH (Msg4 HARQ feedback) and PUSCH (Msg3) during the initial access procedure. In these cases, frequency hopping can be configured and the associated PRBs are determined based in the initial UL BWP configuration, which may have a bandwidth larger than the maximum RedCap UE bandwidth. Similar to the RACH occasion issue, few contributions discuss potential solutions, which include:

* Proper RF-retuning for RedCap [1, 18, 19]
* Separate PUCCH configuration for Redcap (e.g., disabled, or different hopping) [19]

**Medium Priority Question 2.2-4: What, if any, techniques should be considered to avoid the case where a PUCCH (for Msg4 HARQ) or PUSCH (for Msg3) falls outside the RedCap UE bandwidth due to frequency hopping?**

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| **Company** | **Comments** | |
| Ericsson | We prefer RF-retuning. Configuring separate PUCCH resources results in fragmentation of PUSCH resources for non-RedCap UEs. The same concern applies to Connected Mode operation. | |
| Intel | As in our response to Question 2.2-2, we do not see the issue based on consideration of initial UL BWP for RedCap UEs not being wider than RedCap UE’s BW (irrespective of it being shared with non-RedCap UEs or not). | |
| Vivo | We would like to prioritize the solution not requiring UE to do RF-retuning. | |
| Huawei | We prefer to consider proper RF retuning. | |
| OPPO | Not see very strong reason why PUCCH or PUSCH shall be transmitted in an initial UL BWP wider than Redcap UE’s bandwidth.  Initial UL BWP for Redcap UE shall be configured with a bandwidth smaller than its bandwidth. | |
| China Telecom | If RF retuning is applied to avoid the case where a PUCCH (for Msg4 HARQ) or PUSCH (for Msg3) falls outside the RedCap UE bandwidth due to frequency hopping, the additional latency should be considered and evaluated. | |
| ZTE | We show similar view as OPPO.  Shared initial UL BWP can be considered only when an initial UL BWP is not wider than Redcap UE’s bandwidth. | |
| Samsung | We also prefer retuning for this case. eMTC supports frequency hopping outside of a narrow band. We don’t think this will increase burden for UE. However, this could provide better coexistence with legacy and better performance. | |
| Sharp | There is no issue if initial UL BWP for RedCap UEs is ensured to be confined within maximum UE bandwidth (with/without dedicated initial UL BWP) | |
| Qualcomm | We support solutions that do not require RF retuning by RedCap UE.  Early indication based on PRACH is a solution that enables separate scheduling for msg3/msgA PUSCH/PUCCH during initial access of RedCap UE.  On the other hand, disabling (intra-slot) frequency hopping compromises the UL coverage of msg3/msgA PUSCH of non-RedCap UE, which is not desirable. | |
| FUTUREWEI2 | Seems a bit related to the next question, and how some of the FFS progress in the agreement in the last GTW. Would prefer a clear or no decision here (for now) rather than a bunch more options and FFS. | |
| Nokia, NSB | We do not support BWP larger than maximum RedCap UE bandwidth. This question can be revisited once the BWP issue is resolved. | |
| TCL | We prefer UE not to do RF-retuning. | |
| Xiaomi | We are OK with both solutions.  The RF retuning based solution could enable Redcap hop within a large frequency range to achieve better frequency diversity gain. While how to handle the RF retuning gap should be carefully addressed to avoid SE degradation, for example dropping certain symbol in the RF retuning gap is not desirable.  Separate PUCCH configuration could avoid the restriction on the frequency hopping range of non-Redcap and also avoid addition specific handling of the PUCCH or PUSCH of Redcap, e.g., RF retuning can be avoided in this case. | |
| NEC | We prefer solutions not to require RF-retuning. RedCap UE should not be expected to be configured with such a case. | |
| DOCOMO | Following two cases should be considered:   * If RedCap UEs have shared initial BWP with non-RedCap UEs: Proper RF-retuning   If RedCap UEs have separate initial BWP from non-RedCap UEs: No enhancement is necessary | |
| CATT | For Msg3, it may not be a serious problem, since whether hopping or not is controllable and the performance can be improved by link adaptation.  For PUCCH for Msg4, which is always hopping, we prefer not requiring RF-retuning. Performance for control information should be carefully guaranteed. Even symbol-level abandoning due to RF-retuning will increase detection failure probability, especially for short format PUCCH. | |
| LG | The following techniques can be considered for further study and discussion.   * Turning off the frequency hopping * Frequency hopping within the RedCap bandwidth for initial access (e.g., 20MHz for FR1) * RF retuning * Separate initial UL BWP | |
| Lenovo, Motorola Mobility | This depends on whether we will have wider initial UL BWP than UE BW. | |
| CMCC | In most cases, there is no strong motivation to reconfigure a larger initial BWP, which is not power efficient for UEs. In the early phase of network deployment, and when dynamic BWP switching is not support, one larger initial BWP may be configured to avoid frequency fragmentation and make sure UE can fully use the large frequency resource. However, when dynamic BWP switching is support, the 20MHz initial BWP can locate at the edge of carrier to minimize the fragment, and UE switches to a larger BWP when needed, then the motivation become smaller. And when the initial BWP is limited to equal or smaller than 20MHz, RedCap and non-RedCap devices can share the initial BWP without the hopping issues.  And the problem of shared initial BWP is that all the RedCap UEs share the same BWP for initial access with non-RedCap UEs, considering PDSCH and PUSCH data transmission of RedCap UEs, and even some of non-RedCap UEs, the shared initial BWP can be crowed and congestion may happen, that’s why we think separate initial BWP can help, no matter the initial BWP is larger than 20MHz or not.  For the RF retuning, our concern is that it will reduce the demodulation performance of PUCCH and PUSCH. Frequency hopping of such channel is to achieve frequency diversity, and improve coverage, while RF retuning of intra slot transmission may cause two symbols data loss, which leads to the opposite effect. So, the performance loss of RF retuning should be carefully examined. | |
| InterDigital | Agree with NTT DOCOMO’s comment that the solution depends on whether a dedicated initial BWP is present or not. | |
| NordicSemi | Depends on whether separate ROs and/or separate initial BWP are defined for REDCAP or not. | |
| MediaTek | We don’t prefer to do RF-retuning. No need to support BWP larger than maximum RedCap UE bandwidth. | |
| **Company** | **Y/N** | **Comments** | |
| FL4 |  | Based on the received responses, the following proposal can be considered.  **Medium Priority Proposal 2.2-4a:**   * The following options to address the case where a PUCCH/PUSCH occasion falls outside the RedCap UE bandwidth are FFS.   + Option 1: Proper RF-retuning for RedCap   + Option 2: Separate initial UL BWP for RedCap UEs   + Option 3: Separate PUCCH configuration for Redcap (e.g., disabled, or different frequency hopping) | |
| Qualcomm | Y |  | |
| Intel | N | We would like to add another option as:  Option 4: Via gNodeB configuration (e.g., limiting UL initial BWP to BW no more than RedCap UE max BW) | |
| DOCOMO | Y |  | |
| Huawei, HiSi | Y |  | |
| Xiaomi | Y |  | |
| LG | Y |  | |
| vivo | N | We have following comments to the proposal above   1. The issue may only happens during initial access procedure, so it is important to clarify that the PUCCH is the MSG4 HARQ-ACK, and PUSCH is the MSG3 PUSCH. The point is that even if we adopt some special solutions here, we do not think it is proper to continue using it during RRC connected state. 2. Similar as the RACH issue, another option 4 should be added    1. Option 4: gNB configuration (e.g., restrictions on the schedulable BW for MSG 4 HARQ-ACK and MSG3 PUSCH) | |
| OPPO |  | It depends on whether an initial UL BWP larger than Redcap UE’s BW is allowed.  Before the BWP issue is clear, there is no need to discuss this issue. | |
| CATT | Y | Also fine to clarify the use case of PUCCH and PUSCH here, e.g. the origin version of this proposal like ‘**PUCCH (for Msg4 HARQ)’** and **‘PUSCH (for Msg3)**’ | |
| TCL | Y |  | |
| NEC |  | OK to add option 4 mentioned by Intel and vivo | |
| Apple | N | We support adding Opt.4 as proposed by Intel and Vivo. | |
| CMCC | Y | We think gNB always has the flexibility to configure an initial BWP with BW no larger than Redcap UE’s BW, then all the initial acess procedure can be reused.  This propopal talks about the configuration when an initial BWP larger than 20MHz is configured, then the three options can be further studied. | |
| Sharp | Y |  | |
| ZTE |  | Show similar view as OPPO  There is no need to discuss this issue before the BWP issue is clear. | |
| Panasonic | Y |  | |
| Samsung | Y | Also Ok to add option 4 | |
| Spreadtrum |  | We share the similar views with OPPO. | |
| Lenovo, Motorola Mobility | Y |  | |
| Nokia, NSB | N | We do not support initial BWP larger than maximum UE BW. It’s better to agree on the initial BWP bandwidth before considering this. | |
| NordicSemi | Y | If this is kept as FFS, then OK. But this is not a priority question to resolve, first we should sort out whether BWP can be larger than UE REDCAP capability | |
| InterDigital | Y |  | |
| SONY | Y |  | |
| FUTUREWEI4 |  | Similar to our answer to the last question, this issue can also be avoided altogether by network configuration (e.g., limiting the initial UL BWP to the RedCap UE bandwidth). Opt 4 as proposed by Intel is one way to clarify. | |
| Ericsson | Y | Also fine to add clarification proposed by Vivo and CATT. | |
| FL5 Medium |  | Based on the received responses, the following proposal can be considered, where the changes compared to Proposal 2.2-4a are in the main bullet and the new sub-bullet for Option 4.  **Medium Priority Proposal 2.2-4b:**   * The following options to avoid the case where a PUCCH (for Msg4 HARQ feedback) and PUSCH (for Msg3) occasion falls outside the RedCap UE bandwidth are FFS.   + Option 1: Proper RF-retuning for RedCap   + Option 2: Separate initial UL BWP for RedCap UEs   + Option 3: Separate PUCCH configuration for RedCap (e.g., disabled, or different frequency hopping)   + Option 4: gNB configuration (e.g., limiting UL initial BWP to bandwidth no more than RedCap UE max bandwidth, or restrictions on the schedulable bandwidth for Msg4 HARQ feedback and Msg3 PUSCH) | |
| FL6 |  | Proposal 2.2-4b was discussed and updated in the following way in an online (GTW) session on Monday 1st February.  **Medium Priority Proposal 2.2-4c:**   * Study further how to enable/support that PUCCH (for Msg4/MsgB HARQ feedback) and/or PUSCH (for Msg3/MsgA) transmissions fall within the RedCap UE bandwidth, with the following options:   + Option 1: Proper RF-retuning for RedCap   + Option 2: Separate initial UL BWP for RedCap UEs   + Option 3: Separate PUCCH/Msg3/MsgA PUSCH configuration or a different interpretation for the same configuration for RedCap (e.g., disabled frequency hopping or different frequency hopping)   + Option 4: gNB configuration (e.g., always restricting the initial UL BWP to within RedCap UE bandwidth, or restrictions on the schedulable bandwidth for Msg4/MsgB HARQ feedback and Msg3/MsgA PUSCH)   + Other options are not precluded | |
| Qualcomm | Y |  | |
| NEC | Y |  | |
| CATT | Y, mostly | Considering that it is unclear whether 2-step RACH will be supported by RedCap UE or not, we should put square brackets to MsgA and MsgB as [MsgA] and [MsgB].  We can come back to this later after the situation is clearer. | |
| LG | Y | Also okay with the changes from CATT | |
| Xiaomi | Y, mostly | For the last part of Option 4, we suggest to change “schedulable bandwidth” to “frequency location and the amount of scheduled resource” to make the description more specific and clear.  We are also OK with CATT’s suggestion. | |
| vivo | Y |  | |
| DOCOMO | Y | Also agree with CATT that square brackets should be put to MsgA/MsgB | |
| TCL | Y | Also agree with CATT’s suggestion. | |
| China Telecom | Y | We are fine with CATT’s suggestion. | |
| Intel | Y | Also fine with CATT’s suggestion. | |
| Samsung | Y |  | |
| Sharp | Y | We are OK with CATT’s suggestion. | |
| OPPO |  | Not sure whether 2-step RACH shall be supported for Redcap use cases. Pease note that 2-step RACH is for low latency access. | |
| ZTE | Y | We are fine with CATT’s suggestion. | |
| CMCC | Y | We are fine with CATT’s suggestion. | |
| Lenovo, Motorola Mobility | Y |  | |
| Huawei, HiSi | Y |  | |
| Nokia, NSB | Y |  | |
| NordicSemi | Y with small update | 1) My only minor comment in online was that MSG3 location is dynamically indicated in MSG2 PDSCH, i.e. not configured (or even partially). While e.g. PUCCH resource is configured+indicated  Option 3: Separate PUCCH/Msg3/MsgA PUSCH configuration/indication or a different interpretation for the same configuration/indication for RedCap (e.g., disabled frequency hopping or different frequency hopping)  2) We think that REDCAP should not be limited to 4-step RACH only.   1. Again should have been starting point for PRACH/PUSCH/PUCCH in initial BWP>20MHz:  * For the case when initial BWP is larger than maximum RedCap BW (if supported), study further how to enable/support that PUCCH (for Msg4/MsgB HARQ feedback) and/or PUSCH (for Msg3/MsgA) transmissions fall within the RedCap UE bandwidth, with the following options:   + Option 1: Proper RF-retuning for RedCap   + Option 2: Separate initial UL BWP for RedCap UEs   + Option 3: Separate PUCCH/Msg3/MsgA PUSCH configuration or a different interpretation for the same configuration for RedCap (e.g., disabled frequency hopping or different frequency hopping)   + Option 4: gNB configuration (e.g., ~~always restricting the initial UL BWP to within RedCap UE bandwidth, or~~ restrictions on the schedulable bandwidth for Msg4/MsgB HARQ feedback and Msg3/MsgA PUSCH)   + Other options are not precluded | |
| FUTUREWEI6 | Y | We are fine with CATT’s suggestion. We should focus on the 4 step RACH procedure first. | |
| Ericsson | Y | Also fine with CATT’s suggestion. | |
| FL7 |  | Based on the received responses, the following proposal can be considered.  **Medium Priority Proposal 2.2-4d:**   * For the case when initial BWP is larger than maximum RedCap BW (if supported), study further how to enable/support that PUCCH (for Msg4/[MsgB] HARQ feedback) and/or PUSCH (for Msg3/[MsgA]) transmissions fall within the RedCap UE bandwidth, with the following options:   + Option 1: Proper RF-retuning for RedCap   + Option 2: Separate initial UL BWP for RedCap UEs   + Option 3: Separate PUCCH/Msg3/[MsgA] PUSCH configuration/indication or a different interpretation for the same configuration/indication for RedCap (e.g., disabled frequency hopping or different frequency hopping)   + Option 4: gNB configuration (e.g., ~~always restricting the initial UL BWP to within RedCap UE bandwidth, or~~ restrictions on the ~~schedulable bandwidth~~ frequency location and the amount of scheduled resource for Msg4/[MsgB] HARQ feedback and Msg3/[MsgA] PUSCH)   + Other options are not precluded | |
| Intel | N | Given that now we go back to the hypothetical scenario of support of initial BWP larger than RedCap BW (pending decision), we prefer to come back to the current proposal once we close on support of BW larger than RedCap UE BW. | |
| Qualcomm | Y | We are ok with the suggestion of CATT on 2-step RACH. | |
| DOCOMO | N | We prefer previous version of not having the modification of initial BWP larger than maximum RedCap BW by NordicSemi, to align with RO agreement in the last GTW session. | |
| LG | Y | We are okay with the changes made in the latest version. But, if companies have concerns with the latest version especially for the leading part of the main bullet, then we are also okay to go back to the previous version and make necessary changes. Hope the third comment from NordicSemi was not a very critical one but just for clarification. | |
| Lenovo, Motorola Mobility | Y | We can live with this version, but also agree that align the wording with the previous agreement on RO might be better. | |
| Apple | No | Our view is that we should first discuss and conclude whether or not to allow the configuration that initial UL BWP is larger than 20MHz supported by Redcap UE and what is the exact use case(s). After that, we can move forward to discuss the potential solutions, if supports. We should not mess up these two together. | |
| CATT | Y, partially | We are fine with the modified sub-bullets. But we are not sure if the main bullet is accurate enough. To us, at least the ‘initial BWP’ should be changed to ‘initial UL BWP’. In this proposal, we are not discussing the case ‘if initial DL BWP bandwidth > RedCap UE bandwidth’. | |
| Xiaomi | Y |  | |
| NEC | N | We prefer the previous version modified during GTW with updates by CATT similar formulation as RO. | |
| vivo | N | We prefer the previous version due to the same reason provided by companies above. | |
| Huawei | Y and | Propose to add one more option: One or multiple initial UL BWP starting positions for RedCap UEs, i.e.   * For the case when initial BWP is larger than maximum RedCap BW (if supported), study further how to enable/support that PUCCH (for Msg4/[MsgB] HARQ feedback) and/or PUSCH (for Msg3/[MsgA]) transmissions fall within the RedCap UE bandwidth, with the following options:   + Option 1: Proper RF-retuning for RedCap   + Option 2: Separate initial UL BWP for RedCap UEs   + Option 3: Separate PUCCH/Msg3/[MsgA] PUSCH configuration/indication or a different interpretation for the same configuration/indication for RedCap (e.g., disabled frequency hopping or different frequency hopping)   + Option 4: gNB configuration (e.g., ~~always restricting the initial UL BWP to within RedCap UE bandwidth, or~~ restrictions on the ~~schedulable bandwidth~~ frequency location and the amount of scheduled resource for Msg4/[MsgB] HARQ feedback and Msg3/[MsgA] PUSCH)   + Option 5: One or multiple initial UL BWP starting positions for RedCap UEs   + Other options are not precluded | |
| Samsung | Y | Support CATT’s suggestion to add “UL” for main bullet.  For the case when initial UL BWP is larger than maximum RedCap BW (if supported)  For HW’s option 5, we think it can be covered by option 2 by adding (s), as for RO   * + Option 2: Separate initial UL BWP(s) for RedCap UEs | |
| ZTE |  | Change the main bullet to:   * For the case when initial UL BWP configured for legacy NR UEs is larger than maximum RedCap BW, study further how to enable/support that PUCCH (for Msg4/[MsgB] HARQ feedback) and/or PUSCH (for Msg3/[MsgA]) transmissions fall within the RedCap UE bandwidth, with the following options: | |
| OPPO | Y | Support ZTE’s version.  The main bullet is more clearer than previous versions.  Also support option 5 proposed by Huawei. | |
| Spreadtrum |  | We share the similar views with DOCOMO | |
| Sharp | Y | Support ZTE’s modification on the main bullet. | |
| SONY | Y | We are OK with this proposal. Main bullet should preferably refer to “initial UL BWP”, as commented by other companies. | |
| CMCC |  | We prefer the previous version, which is aligned with RO case. With the condition, “For the case when initial BWP is larger than maximum RedCap BW (if supported)”, there are two understanding for the modified option 4, one is gNB restrict the scheduling resource of both RedCap and non-Redcap UEs without early identification, this will limit the scheduling flexibility of gNB. And the other one is with early identification, gNB only schedules RedCap UE on specific resources, this is similar with option 3. So it’s better to keep the former proposal. | |
| Nokia, NSB | Y | We are OK with the proposal and support to clarify the proposal is for UL BWP as well. | |
| NordicSemi | Y | Correct, proposal should be for initial UL BWP. But ZTE formulation sounds like RAN1 would already support initial UL BWP (for the RedCap UE) to be larger than REDCAP UE BW capability.   * The initial UL BWP (derived based on SIB) for RedCap UEs can be the same as the initial UL BWP for non-RedCap UEs at least when the initial UL BWP is no wider than the RedCap UE bandwidth.   + FFS: during and after initial access, whether a RedCap UE is allowed to operate with an initial UL BWP wider than the maximum RedCap UE bandwidth   General comment: To us the **Proposal 2.2-4d** is saying the same as **Proposal 2.2-4c** but is in fact much more clearly saying that the discussion is relevant only if initial UL BWP can be larger than RedCap BW. Therefore, I do not understand for example companies saying NO to **Proposal 2.2-4d** and Yes to **Proposal 2.2-4c** **,** and at the same time saying that there should be a prioritization of discussion. 😊  Anyway, if all companies are fine with **Proposal 2.2-4c** with square brackets on 2-step RACH and “indicated” edit, we are also fine with **Proposal 2.2-4c** | |
| InterDigital | Y |  | |
| FUTUREWEI7 | N | As discussed in the GTW, the gNB configuration solution to use the same BWP should be clearly visible. The latest update makes this even worse by removing that from Opt 4 and writing the preamble to suggest the issue must be solved by one of these solutions. A first bullet should be added as below, and the “how” should be “how/whether”.   * When the initial UL BWP is the same for RedCap and non-RedCap UEs, the PUCCH and PUSCH are within the RedCap UE bandwidth | |
| Ericsson | Y | We are fine with Proposal 2.2-4c or Proposal 2.2-4d with the suggested revision from CATT. Adding square brackets to “MsgA” and “MsgB” is fine with us. | |
| FL8 Medium |  | Based on the received responses, the following proposal can be considered.  The update of Option 2 is intended to address the comment from Huawei, as suggested by Samsung.  **Medium Priority Proposal 2.2-4e:**   * ~~For the case when initial BWP is larger than maximum RedCap BW (if supported),~~ ~~s~~Study further whether and how to enable/support that PUCCH (for Msg4/[MsgB] HARQ feedback) and/or PUSCH (for Msg3/[MsgA]) transmissions fall within the RedCap UE bandwidth, with the following options:   + Option 1: Proper RF-retuning for RedCap   + Option 2: Separate initial UL BWP(s) for RedCap UEs   + Option 3: Separate PUCCH/Msg3/[MsgA] PUSCH configuration/indication or a different interpretation for the same configuration/indication for RedCap (e.g., disabled frequency hopping or different frequency hopping)   + Option 4: gNB configuration (e.g., ~~always restricting the initial UL BWP to within RedCap UE bandwidth, or~~ restrictions on the ~~schedulable bandwidth~~ frequency location and the amount of scheduled resource for Msg4/[MsgB] HARQ feedback and Msg3/[MsgA] PUSCH)     - Note: When the initial UL BWP is the same for RedCap and non-RedCap UEs, the PUCCH (for Msg4/[MsgB] HARQ feedback) and PUSCH (for Msg3/[MsgA]) are within the RedCap UE bandwidth   + Other options are not precluded | |
| FL9 |  | Proposal 2.2-4e was discussed and updated as indicated below in an online (GTW) session on Wednesday 3rd February.  **Medium Priority Proposal 2.2-4f:**   * Study further whether and how to enable/support that PUCCH (for Msg4/[MsgB] HARQ feedback) and/or PUSCH (for Msg3/[MsgA]) transmissions fall within the RedCap UE bandwidth, with the following options:   + Option 1: Proper RF-retuning for RedCap   + Option 2: Separate initial UL BWP(s) for RedCap UEs with one or more starting positions   + Option 3: Separate PUCCH/Msg3/[MsgA] PUSCH configuration/indication or a different interpretation for the same configuration/indication for RedCap (e.g., disabled frequency hopping or different frequency hopping)   + Option 4: gNB configuration (e.g., always restricting the initial UL BWP to within RedCap UE bandwidth, or restrictions on the frequency location and the amount of scheduled resource for Msg4/[MsgB] HARQ feedback and Msg3/[MsgA] PUSCH)     - Note: As an example, when the initial UL BWP is the same for RedCap and non-RedCap UEs, the PUCCH (for Msg4/[MsgB] HARQ feedback) and PUSCH (for Msg3/[MsgA]) are within the RedCap UE bandwidth   + Other options are not precluded | |
| Huawei | Y |  | |
| NEC | Y |  | |
| TCL | Y |  | |
| China Telecom | Y |  | |
| Qualcomm |  | We have concerns on the broad scope of FFS, considering the different views of companies at GTW discussion.  Some additional comments on Option 1 and Option 2.  Option 2:   * we don’t think the phrase “with one or more starting positions” is needed. * We are fine with the wording in FL8 proposal   Option 1:   * we don’t think RF-retuning of BWP is a feasible solution, if gNB does not know the presence of RedCap UE before processing msg3 (or msgA). As shown by the figure below for FR1 RedCap UE:   + when gNB attempts to decode msg3/PUCCH/msgA PUSCH from a RedCap UE and interprets RF retuning gap (𝑇\_𝑔𝑎𝑝) as part of the 2nd hop of a non-RedCap UE, channel estimation (or correlation) is messed up and decoding fails;   + as a result, a RedCap UE cannot complete the RACH procedure and establish connection with gNB | |

## BWP operation

Several contributions [1, 4, 8, 11, 18, 20, 22, 26] highlight different aspects related to the BWP operation for RedCap UEs after the initial access. These aspects include BWP switching mechanisms and narrow BWP operation for power saving and potentially SSB-based measurements [1, 4, 18, 22], BWP hopping for frequency diversity and interference mitigation [11, 22], operating in a wide BWP [19, 20], and fast BWP switching to dedicated BWP for offloading the initial BWP [26].

Meanwhile, some contributions [8, 11, 20] raise questions regarding the BWP switching time and RF retuning delay and propose to send an LS to RAN4.

One contribution [10] suggests that the support of multiple BWP could be optional for RedCap UE.

**Medium Priority Question 2.3-1: What, if any, BWP switching mechanisms are needed for RedCap Ues in addition to existing BWP switching mechanisms?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Comments** | |
| Ericsson | It is sufficient to support existing BWP switching mechanisms. | |
| TCL | Redcap Ues switching to the dedicated BWP immediately after random access procedure may be considered to offload Ues from initial BWP. | |
| Vivo | The existing BWP switching mechanism seems sufficient. | |
| Huawei | Need to identify the scenarios that may cause frequency retuning and discuss the necessary scheduling delay or guard period of RF retuning. | |
| Samsung | Existing BWP switching mechanism is not designed for frequently switch. However, to provide better coexistence with non-Redcap UE, Redcap Ues is better to be able to be scheduled within the same frequency range as non-Redcap Ues. So, either Redcap operation in a wider BWP or some faster BWP switching assuming same SCS is beneficial. | |
| OPPO | It depends on whether frequently switch is needed for redcap UE to get frequency hopping gain outside its narrow BWP (configured for power saving). If yes, the BWP switching delay requirement shall be revisited to facilitate such frequency hopping mechanisms. | |
| ZTE | Need to evaluate BWP switching delay for RedCap Ues since the maximum UE bandwidth of RedCap Ues is much smaller than legacy Ues.  Considering the frequency diversity gain of 20MHz is large enough and possible significant spec impacts, we think there is no need to consider RedCap Ues to operate in a BWP wider than maximum UE bandwidth of RedCap Ues in Rel-17. | |
| Qualcomm | In FR1, it is sufficient to support existing BWP switching mechanism for R17 RedCap UE.  In FR2, the following aspects can be considered if time allows:   * Consider switching the UE to a narrow active BWP (NBWP) after initial access is complete. The switching may be:   + Network initiated/controlled (already existing in NR R15/16)   + Implicit: Based on a random selection or some UE ID hashing function   + UE initialed/requested     - UE may send a preferred max UE BW (≤ 100 MHz) to be used after initial access     - UE may send a preferred BWP to be used after initial access * Utilizing BWP hopping to reduce the NB interference effects   + Includes methods to reduce the BWP switching gap effects, e.g.:     - Variable hop BWP time (extension)     - BWP hop skipping/modification     - Define smaller BWP switching times by preconfiguring the hops and by using similar BWP parameters   + Send LS to RAN4 to inquire about switching gaps between preconfigured BWPs with the same configurations (no DCI reading) | |
| FUTUREWEI2 | It may be worth asking RAN4 about whether faster BWP switching is possible | |
| Nokia, NSB | The existing BWP switching mechanism is sufficient. | |
| Xiaomi | straightforward BWP framework for Redcap is that a narrow BWP is configured for Recaps so that the Redcap devices could monitor all the frequency resource in the BWP. While we see the following drawbacks:   * some loss in frequency diversity / frequency selective gain * within a narrow BWP, it is not efficient to include SSB in each BWP, then the Redcap would switch to the BWP including SSB to do the SSB measurement for RLM/RRM   To address the above drawbacks, we think the following two directions worth consideration  - Direction 1: Support configuring BWP larger than the maximum UE bandwidth. RF retuning can be utilized to different resource of the wide BWP  - Direction 2: Optimize the BWP framework to reduce the switching gap | |
| Intel | A simplified BWP hopping framework can be beneficial to recover against lost diversity via some variations in the channel and interference. In this context, numerology and most RRC configurations can be maintained the same across the BWPs. In this regard, we would also support sending an LS to RAN4 on switching times under such conditions and with potential bounding of the “hopping distance” for the BWP center frequencies. | |
| NEC | The existing BWP switching mechanism should be sufficient for reduced capability devices. | |
| DOCOMO | The existing BWP switching mechanism is sufficient | |
| CATT | From mechanisms point of view, the existing BWP switching mechanisms should be sufficient (e.g. RRC configured-based, DCI-based, timer-based).  Maybe the switching time can be different, e.g. a larger switching time may be needed, if confirmed by RAN4. | |
| LG | Don’t see any issue to support RedCap with the existing BWP switching mechanism. Faster BWP switching may be helpful for NR devices in general, which can be discussed separately perhaps not in this WI. Frequency hopping across BWP has little motivation compared to eMTC as the bandwidth of RedCap is same as normal LTE devices which is much larger the eMTC. These are considered as not essential but nice-to-have features that can be sought along with the evolution. | |
| Lenovo, Motorola Mobility | The existing BWP switching mechanism maybe sufficient. We are also open for additional BWP switching if beneficial. | |
| CMCC | The existing BWP switching mechanism is sufficient. | |
| InterDigital | The existing mechanism may be sufficient; switching time may be investigated further. | |
| NordicSemi | Existing BWP switching is enough, however, assuming that reduced capability UE will be capable to support configuration of many non-overlapping BWPs is not very realistic. | |
| MediaTek | We think it is sufficient to support existing BWP switching mechanisms. | |
| **Company** | **Y/N** | **Comments** |
| FL4 |  | Based on the received responses, the following proposal can be considered.  **Medium Priority Proposal 2.3-1a:**   * For BWP switching for RedCap Ues:   + FFS: Whether the currently defined BWP switching delay is sufficient to accommodate RF retuning delay, based on RAN4 confirmation/feedback for FR1 and FR2   + FFS: Whether inter-BWP frequency hopping is supported (for diversity gain) |
| Qualcomm | Y |  |
| Intel | Y |  |
| DOCOMO | Y |  |
| Huawei, HiSi | Y |  |
| Xiaomi | N | The first FFS bullet is not clear to us. In which case, the RF retuning would happened. Does it intend for the case of configuring a wide BWP larger than Redcap’s UE bandwidth? |
| LG |  | For the first FFS, we don’t see any issue to support RedCap with the existing BWP switching mechanism. If what we are trying to do here is an enhancement of the existing BWP switching, then it may be a topic for NR devices in general. However, given the formulation from the FL, with the understanding the intention is to get confirmation/feedback from RAN4, we can live with the first FFS.  For the second FFS, we think the frequency hopping across BWP has little motivation compared to eMTC as the bandwidth of RedCap is same as normal LTE devices which is much larger the eMTC. As we don’t expect substantial gain from this, and also don’t think this is essential to make RedCap work, we prefer to remove the second FFS. As companies can still bring in results to show the benefits and/or gains without the FFS, we can continue discussion anyway. |
| Vivo | N | The 1st FFS is too early to conclude, RAN1 should first agree the use case for RF retuning beyond the existing BWP switching, if agreed, ask RAN4 about whether existing switching time can be reused  The 2nd FFS is not agreeable. The inter-BWP frequency hopping was explicitly discussed during study item and in the WID drafting during RAN#90e, it was not included in the current WID so out of scope. |
| OPPO | Y | BWP hopping is important for redcap Ues:   1. to reduce the NB interference effects 2. get frequency diversity gain when very small BWP is configured for power saving |
| CATT |  | About the 2nd FFS, it is still unclear what is the essential difference between ‘inter-BWP frequency hopping’ and ‘BWP switching’ from RAN1 specification point of view. |
| TCL | Y |  |
| NEC | Y |  |
| Apple |  | We share the view to clarify the targeted use cases first to make potential RAN4 LS more concrete and solid. |
| CMCC | Y |  |
| Sharp | Y |  |
| ZTE |  | The 1st FFS is needed. Considering the reduced capability of RedCap Ues, there is a need to confirm whether the legacy BWP switching delay values are sufficient for RedCap Ues due to RF retuning.  We don’t think there is a need to study inter-BWP frequency hopping for RedCap Ues. Inter-BWP frequency hopping increases the complexity of RedCap Ues and is harmful for the UE’s power consumption. |
| Panasonic | Y |  |
| Lenovo, Motorola Mobility | Y |  |
| Nokia, NSB |  | On the 1st FFS, we are not clear why existing BWP switching delay would not be applicable to RedCap UE. We did not discuss this during our complexity reduction so we feel that RedCap UE should then support existing BWP switching delay.  On the 2nd FFS, we do not think inter-BWP hopping is needed for frequency diversity gain given RedCap 20/100 MHz BW support. |
| NordicSemi | N | If asking RAN4 about further relaxation BWP switching timelines, we should ask for both Dynamic and RRC based BWP switch. Only RRC-based is mandatory in R15/R16  If Vivo is right about BWP hopping RAN discussion, then it should not be discussed in RAN1. |
| InterDigital | Y |  |
| SONY |  | While we are generally OK with the proposal, our understanding of the discussion above and the input documents (e.g. Intel [11], Samsung [20]) was that the BWP switching delay can be reduced if the numerology of the BWPs that are being switched between is the same. So, it seems that the issue is not whether the current BWP switching delay is sufficient, it is whether the BWP switching delay can be reduced.  Text like the following seems to be more in line with the reason for re-visiting BWP switching delays:   * + FFS: Whether the currently defined BWP switching delay ~~is sufficient to accommodate RF retuning delay~~can be reduced when the numerology of BWPs is the same, based on RAN4 confirmation/feedback for FR1 and FR2 |
| FUTUREWEI4 |  | Not against having some FFS here |
| Ericsson | Y | We are also fine to wait. |
| Samsung |  | We are also fine with Sony’s version.  **Medium Priority Proposal 2.3-1a:**   * For BWP switching for RedCap Ues:   + FFS: Whether the currently defined BWP switching delay is sufficient to accommodate RF retuning delay, based on RAN4 confirmation/feedback for FR1 and FR2   + FFS: Whether can acheive faster switching delay assuming the same SCS, based on RAN 4 confirmation/feedback for FR1 and FR2   + FFS: Whether inter-BWP frequency hopping is supported (for diversity gain) |
| FL5 Medium |  | Based on the received responses, it seems that this topic can be treated (if needed) once other topics have been progressed a bit further. |

## Bandwidth after initial access

Several contributions [1, 2, 3, 5, 7, 9, 15, 16, 18, 19, 20, 21, 22, 26, 28] express views on whether a wider bandwidth than 20 MHz, up to 40 MHz, should be optionally supported after initial access. According to the WID, this case will be further discussed in RAN#91e.

## Other prioritized impacts of reduced maximum UE bandwidths

**Medium Priority Question 2.5-1: What, if any, other potential RAN1 specification impacts from reduced maximum UE bandwidths (beyond the impacts discussed in previous sections in this document) do you think should be prioritized in this meeting?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Comments** | |
| Ericsson | None | |
| vivo | None | |
| Huawei | Same answer as that for 2.3-1. | |
| Samsung | We suggest to discuss whether support UE operates in a wider BWP or not, and the corresponding enhancements:  For UE operates in UE-specific BWP no larger than RF bandwidth, CSI acquisition outside active BWP across the entire carrier BW is needed. Otherwise, it’s impossible for the NW to switch RedCap Ues to an ideal BWP with best channel condition. Enhancement such as SRS transmissions or CSI report for link adaptation outside active BWP can be considered.  For UE operates in wider BWP, at least the following can be further studied: retuning time, hopping rule, resource allocation, CSI measurement and report. | |
| China Telecom | None | |
| Sharp | None | |
| Qualcomm | In FR1, we don’t see a need to prioritize any other topic.  In FR2, the following aspects can be considered if time allows:   * Reusing RS’s for different purposes (e.g., use DMRS for beam management) * Reusing RS between RedCap and non-RedCap Ues (e.g., CSI-RS duplication may be reduced by sharing WB RS with NB RedCap) * Pre-configurations for certain message types (e.g., DCI-less/preconfigured re-tx resources) * On-demand or event-based operation (e.g., event-based L1-meas reports, UE requested/on-demand CORESETs | |
| FUTUREWEI2 | None | |
| Nokia, NSB | None | |
| TCL | None | |
| Xiaomi | Similar consideration, we think support UE operates in a wider BWP should be studied. Wide-band BWP operation could provide better channel selective/ frequency diversity gain. In addition, RF retuning within a wide BWP incurs less switching time when performing the SSB based measurement. | |
| Intel | None | |
| OPPO | If Redcap UE is configured with narrow BWP for power saving, the frequency diversity gain will be impacted. We propose to study mechanism to get frequency diversity gain, such as frequency hopping. | |
| NEC | None | |
| DOCOMO | As a design principle, fragmentation of PUSCH resource for non-RedCap Ues should be avoided especially when a non-RedCap UE uses DFT-s-OFDM | |
| CATT | None | |
| LG | None | |
| CMCC | None | |
| InterDigital | None. | |
| **Company** | **Y/N** | **Comments** |
| FL4 |  | Based on the received responses, the following proposal can be considered.  **Medium Priority Proposal 2.5-1a:**   * For RRC-configured BWPs for RedCap Ues:   + FFS: Whether to support RedCap UE operation in a BWP wider than the RedCap UE bandwidth   + FFS: Whether to support mechanisms for frequency diversity if RedCap Ues operate on BWP not wider than the RedCap UE bandwidth   + FFS: Whether and how to avoid or reduce fragmentation of PUSCH resources for non-RedCap Ues |
| Qualcomm | Y |  |
| Intel | Y |  |
| DOCOMO | Y |  |
| Huawei, HiSi | Y |  |
| Xiaomi | Y |  |
| LG | N | We think the first two FFS above should not be prioritized. They are not essential and the benefits are not clear yet. For the third FFS, it feels it is kind of a design principle taking into account the coexistence with legacy Ues. That principle has been there form the start and is quite clear from the WID. We don’t think this proposal is needed. |
| Vivo | N | The 1st and 2nd FFS are not agreeable. The UE operation in a wider BWP was explicitly discussed during study item and in the WID drafting during RAN#90e, it was not included in the current WID so out of scope.  Fine to keep the 3rd FFS as it somehow related to the coexistence of redcap Ues and non-redcap Ues. But technically we do not think this is a new problem created by Redcap, since Rel-15 we support configuring different UL BWP sizes for different Ues, so gNB should be able to handle the “PUSCH fragmentation” issue, if exists. |
| OPPO | Partially Y | We don’t see the need to configure a large BWP than Redcap UE’s BW when the UE in RRC connected states. |
| CATT |  | The 1st and 2nd FFS are some detailed mechanism while the 3rd FFS is more like a design principle. This makes it unclear what is the attempt for this proposal. |
| TCL | Y |  |
| NEC | Y |  |
| Apple | N | We do not see the justification to configure a UE-specific BWP that is larger than the reported UE capability.  On the 2nd FFS, it is better to clarify ‘frequency diversity’ operation, e.g., across different Redcap BW within a CC or something else. |
| CMCC |  | The second FFS is not clear enough. If it means the inter-BWP hopping, there is already one similar FFS in Proposal 2.3-1a. |
| Sharp | Y |  |
| ZTE | N | For 1st bullet, we think there is no need to configure a large BWP than Redcap UE’s BW when the UE in RRC\_Connected.  For 2nd bullet, existing mechanisms for frequency diversity can be reused for RedCap Ues if BWP is not wider than the RedCap UE bandwidth. There is no need to study RedCap dedicated solutions.  For the 3rd bullet, ‘PUSCH fragmentation’ of non-RedCap Ues is not a new issue. Enhancement in RedCap WID cannot resolve the ‘PUSCH fragmentation’ issue of non-RedCap Ues. |
| Panasonic | Y | We support the proposal 2.5-1a as it is.  We also agree to study whether to support BWP wider than RedCap UE BW. Our view is that wider BWP is beneficial for more flexible frequency resource allocation and then the better co-existence with the non-RedCap UE. |
| Samsung | Y |  |
| Spreadtrum | Partially Y | It is not necessary to support a larger DL BWP than Redcap UE’s BW.  FFS for UL BWP. |
| Lenovo, Motorola Mobility | Y |  |
| Nokia, NSB |  | We don’t support 1st and 2nd bullets. We also don’t really see a need for 3rd bullet but are OK to consider it.  On the 1st bullet, we do not see the justification to configure BWP wider than the maximum UE BW. On the 2nd bullet, we think 20/100 MHz is large enough to provide frequency diversity gain. If UE is configured on narrow BW for power saving, it can be switched to wider BW for data transmission to achieve frequency diversity. |
| InterDigital | Y |  |
| SONY | Y |  |
| FUTUREWEI4 |  | We are not necessarily against FFS, but we do not think we should be repeated the same or similar FFS as to other agreements or proposed agreements. For example, since this says “RRC-configured BWP” and not “non-initial BWP” it may overlap with the FFS we have agreed for initial DL/UL BWPs. We feel we should resolve the initial BWP FFS first before addressing the non-initial DL/UL BWP case. |
| Ericsson | Y |  |
| FL5 Medium |  | Based on the received responses, it seems that this topic can be treated (if needed) once other topics have been progressed a bit further. |
| FL6 |  | Based on the received responses, the following proposal can be considered, where “RRC-configured BWPs” has been changed to “non-initial BWPs”.  Note that the all aspects of the proposal are just FFS. Agreeing to this proposal does not imply that any of the listed aspects are agreed to be supported.  **Medium Priority Proposal 2.5-1b:**   * For non-initial BWPs for RedCap Ues:   + FFS: Whether to support RedCap UE operation in a BWP wider than the RedCap UE bandwidth   + FFS: Whether to support mechanisms for frequency diversity if RedCap Ues operate on BWP not wider than the RedCap UE bandwidth   + FFS: Whether and how to avoid or reduce fragmentation of PUSCH resources for non-RedCap Ues |
| Qualcomm | Y |  |
| NEC | Y |  |
| CATT |  | Replacing ‘RRC-configured’ by ‘non-initial’ makes the scenario clearer. However, it seems the concerns from companies listed above are not solved.   * It is unclear what mechanism exactly means in detail in the 2nd FFS (inter-BWP hopping?), and we should not easily conclude something to be supported or not before it is well-understood. * Same questions to 3rd FFS. It reads like design principle rather than detailed mechanism. If it is a design principle, it may be improper to be juxtaposed with the 1st and 2nd FFS. In this case, we are fine to remove either the 3rd FFS or the 1st +2nd FFS (if the 2nd FFS is well descripted/revised). |
| LG |  | We don’t support this proposal. Repeating the same comment, as nothing has changed, the first two FFS above are not essential and the benefits are not clear yet. For the third FFS, it feels it is kind of a design principle taking into account the coexistence with legacy Ues. That principle has been there from the start and is quite clear from the WID. |
| Xiaomi |  | Generally, we are OK with the intension of proposal.  For the second FFS bullet, some update may be needed to make it clear. In our understanding, the intension of second FFS bullet is to study the inter-BWP frequency hopping. Furthermore, we think the inter-BWP frequency hopping should not be restricted for the case that RedCap Ues operate on BWP not wider than the RedCap UE bandwidth. So we suggest the following revision for the second FFS bullet   * + FFS: Whether to support inter-BWP frequency hopping ~~mechanisms~~ for frequency diversity ~~if RedCap Ues operate on BWP not wider than the RedCap UE bandwidth~~ |
| vivo | N | We do not agree with this proposal.  The previous discussion about wider bandwidth issue during initial access was due to co-existence where there are some tradeoffs has to be taken care by the gNB between non-redcap and redcap, so we are fine to discuss further.  This proposal, is however related to RRC-connected mode where gNB already knows the redcap bandwidth capability and no impact to non-redcap Ues. gNB should configure the BWP according to the UE capability, therefore no issue exists. The proposals here (1st and 2nd FFS) are unnecessary optimizations for some diversity gain, they have been discussed during the study item without conclusion or recommendation thus not included in the WI. Therefore, they are beyond the WID scope we do not think it is worthwhile to reopen this discussion.  The last FFS is not a new issue introduced by redcap Ues, even in the existing network, UE may be configured with different BWPs so if fragmentation is there gNB should be able to handle it already. |
| DOCOMO | Y | Regarding 3rd FFS, if companies have the same understanding that the design principle is quite clear from WID as commented by LG, we are fine to remove it. However, as commented by vivo, companies may have different understanding and may think it is not RedCap-specific issue. We think it depends on the 1st FFS. If RedCap UE can be configured with a BWP wider than the RedCap UE BW (e.g., same as legacy UE), the issue may not be necessary to be addressed. Otherwise, there is RedCap-specific UE behaviour, which should be considered for coexistence with legacy UE |
| TCL | Y |  |
| China Telecom |  | We think it would be better to discuss the issues related to non-initial BWPs for RedCap Ues after further study. In this stage, it may be waste time on discussing such FFS which does not imply that any of the listed aspects are agreed to be supported. |
| Intel | Y | We are also fine with the simplification for the second FFS suggested by Xiaomi. |
| Samsung | Y | Thanks CATT’s to point out the issue:  In our understanding, for current wording of the second FFS, a Redcap UE can use RF-retuning to be scheduled to another BWP with potentially faster BWP switching, for one TB, to achieve frequency diversity gain. This, somehow, redefine the operation of a “BWP”. However, we think BWP switching can be used to achieve frequency selectivity gain, with potential fast BWP switching.  For second FFS, we suggest to combine with proposal 2.3-1 as below:   * For non-initial BWPs for RedCap Ues:   + FFS: Whether to support RedCap UE operation in a BWP wider than the RedCap UE bandwidth   + FFS: Whether to ~~support~~ enhance BWP switching including faster switching assuming same numerology of mulitiple BWPs based on RAN 4’s feedback ~~mechanisms~~ for frequency selectivity [and/or diversity] if RedCap Ues operate on BWP not wider than the RedCap UE bandwidth   + FFS: Whether and how to avoid or reduce fragmentation of PUSCH resources for non-RedCap Ues   We are also open to study on one TB over different BWPs (to keep frequency diversity) if it is supported by majority. |
| OPPO | Partially Y | For the 1st FFS, the motivation to support non-initial BWP larger than Redcap UE’s BW is not clear. Since UE would have been in RRC connected state, it is not reasonable to configure a BWP larger than its capability. Therefore we suggest to remove the 1st FFS.  For the 2nd FFS, the motivation is to 1) avoid the persistent interference in one narrow BWP 2) get frequency diversity gain for narrow BWP. Please note that although a 20MHz maximum channel bandwidth is sufficient to provide adequate diversity gain, **a very small BWP may be configured for the UE for power saving, e.g., for small date rate cases for wearables**. The mechanisms may be BWP switching as pointed out by Samsung and xiaomi. It can be further studied. |
| ZTE |  | We still have the following concerns on the three FFS bullets:  For 1st bullet, we think there is no need to configure a large BWP than Redcap UE’s BW when the UE in RRC\_Connected.  For 2nd bullet, existing mechanisms for frequency diversity can be reused for RedCap Ues if BWP is not wider than the RedCap UE bandwidth. There is no need to study RedCap dedicated solutions.  For the 3rd bullet, ‘PUSCH fragmentation’ of non-RedCap Ues is not a new issue. Enhancement in RedCap WID cannot resolve the ‘PUSCH fragmentation’ issue of non-RedCap Ues. |
| CMCC |  | As we commented before, the second FFS is unclear, frequency diversity is a general description, such as transmit diversity, scheduling schemes to achieve frequency diversity, etc. So it need to be clarified, as already explained by Xiaomi, Samsung, OPPO, details schemes can be added with e.g. |
| Lenovo, Motorola Mobility | Y |  |
| Nokia, NSB |  | Same comment as before. We don’t support 1st and 2nd bullets. We also don’t really see a need for 3rd bullet but are OK to consider it.  On the 1st bullet, we do not see the justification to configure BWP wider than the maximum UE BW. On the 2nd bullet, we think 20/100 MHz is large enough to provide frequency diversity gain. If UE is configured on narrow BW for power saving, it can be switched to wider BW for data transmission to achieve frequency diversity |
| NordicSemi | Y |  |
| FUTUREWEI6 |  | We have similar views as other companies for the 1st FFS. Since a UE would receive configuration for non-initial BWPs in the RRC connected state, the bandwidth of the non-initial BWP should not be larger than the RedCap UE bandwidth. |
| Ericsson | Y | We noticed that a few responses questioned the need for supporting RedCap UE operation in a non-initial BWP wider than the RedCap UE bandwidth. We would like to express our view regarding this.  First for non-initial UL BWP, there is also a potential issue with PUSCH resource fragmentation. Allowing RedCap Ues to operate in a wider non-initial UL BWP is a potential solution addressing this issue. There may be other possible solutions, but at this point we would like to keep this as one of the possible solutions to be studied further.  Furthermore, for FR2, certain SSB/CORESET#0 configurations have a combined bandwidth of SSB and CORESET#0 larger than 100 MHz. We would like to keep the possibility of allowing RedCap Ues to operate in a non-initial DL BWP configured with SSB and CORESET#0 having a combined bandwidth larger than 100 MHz.  Moreover, for both UL and DL non-initial BWPs, we have mentioned in our earlier comments that there are deployed networks using BWP #0 configuration option 2 and supporting only one BWP in the cell, which spans the entire carrier bandwidth. We see a risk of not being able to get all the MNOs currently with such BWP #0 configurations on board if there is no path for allowing their networks to support RedCap Ues with their existing BWP configuration approach. Such a risk can be eliminated if a solution is introduced to allow the RedCap UE to operate in a non-initial BWP with a larger bandwidth. |
| FL7 |  | Based on the received responses, the following proposal can be considered.  Note that the all aspects of the proposal are just FFS. Agreeing to this proposal does not imply that any of the listed aspects are agreed to be supported, nor does it imply that aspects that are not listed are agreed to not be supported.  **Medium Priority Proposal 2.5-1c:**   * For non-initial BWPs for RedCap Ues:   + ~~FFS: Whether to support RedCap UE operation in a BWP wider than the RedCap UE bandwidth~~   + FFS: Whether to support inter-BWP frequency hopping ~~mechanisms~~ for frequency diversity ~~if RedCap Ues operate on BWP not wider than the RedCap UE bandwidth~~   + FFS: Whether and how to avoid or reduce fragmentation of PUSCH resources for non-RedCap Ues   + FFS: Whether and how to support SSB and CORESET#0 having a combined bandwidth larger than the RedCap UE bandwidth in FR2   + FFS: Whether and how to support BWP#0 configuration option 2 supporting a single BWP in the cell |
| Intel | Y |  |
| Qualcomm | Y | We agree with the comments of Vivo that some of the FFS sub-bullets are not necessary, and can be solved within the NR R15/16 framework. On the other hand, we are OK to support this proposal, given the clarification of FL about the intention of this proposal. |
| DOCOMO | Y |  |
| LG |  | Isn’t the last FFS merely a different formulation of the first FFS of Proposal 2.5-1b? For the third FFS, we don’t see a difference from what UE is supposed to do for the initial BWP. That is, gNB configures CORESET#0 bandwidth and UE receives CORESET#0 and SSB by implementation. In general, we don’t think making an agreement with a bunch of FFS is not beneficial unless there is a clear consensus on the benefits or necessity of each of the FFS points. |
| Lenovo, Motorola Mobility | Y | We are a bit confused about the 3rd FFS, i.e.,   * FFS: Whether and how to support SSB and CORESET#0 having a combined bandwidth larger than the RedCap UE bandwidth in FR2.   It seems this case falls in the scope a removed FFS in **Proposal 2.5-1c,**   * FFS: Whether to support RedCap UE operation in a BWP wider than the RedCap UE bandwidth   We prefer to either keep both FFS alive, or discard both. |
| CATT | Y, mostly | We would like to thank the detailed clarification from FL and companies. We will not object if majority has strong interest in this case. A few comments left:   * To align with other FFS, the 1st FFS may also change ‘Whether’ to ‘Whether and how’; * Fot the last FFS, may add ’larger than RedCap UE bandwidth’ to make the motivation more clear and self-contained: Whether and how to support BWP#0 configuration option 2 supporting a single BWP in the cell larger than RedCap UE bandwidth. |
| Xiaomi |  | For the first removed FFS bullet, we still want to keep it. We see the following benefits of supporting Redcap operating in a BWP wider than Redcap’s UE bandwidth.   * Better frequency diversity / selective gain * A wider BWP could accomodate the SSB in easy way. Then when Redcap devices need to perform SSB-based measurement, RF retuning within the wide BWP is sufficient. Otherwise, measurement gap is needed. Considering this point, the interruption on the communication would be smaller.   Considering these benefits, at current stage, we think we can further study it. |
| NEC | Y |  |
| vivo | N | As commented before, to use larger BWP than UE capability has significant implementation impact to UE, please note we are designing for reduced capability Ues, it is not proper to target some optimizations that increase the UE complexity. Our detailed comments for each FFS bullet are as the following   * For non-initial BWPs for RedCap Ues:   + ~~FFS: Whether to support RedCap UE operation in a BWP wider than the RedCap UE bandwidth~~   + FFS: Whether to support inter-BWP frequency hopping ~~mechanisms~~ for frequency diversity ~~if RedCap Ues operate on BWP not wider than the RedCap UE bandwidth~~   [This is an unnecessary optimization, 20MHz already provide enough diversity gain and the required faster switching time increased UE implementation complexity]   * + FFS: Whether and how to avoid or reduce fragmentation of PUSCH resources for non-RedCap Ues   [This is not an redcap UE specific issue. NW should be able to handle it already if different non-redcap Ues are configured with different UL BWPs]   * + FFS: Whether and how to support SSB and CORESET#0 having a combined bandwidth larger than the RedCap UE bandwidth in FR2   [This is not an issue, please refer to the component 4 of Rel-15 UE feature 6-1 Basic BWP operation with restriction (mandatory without capability signalling) as copied below, where it is not required that an RRC configured DL BWP has to be contain both SSB and CORESET#0]   |  | | --- | | 4) BW of a UE-specific RRC configured BWP includes BW of CORESET#0 (if CORESET#0 is present) and SSB for Pcell/PSCell (if configured) and BW of the UE-specific RRC configured BWP includes SSB for Scell if there is SSB on Scell |  * + FFS: Whether and how to support BWP#0 configuration option 2 supporting a single BWP in the cell   [We do not think this is a good motivation to require UE supporting larger BWP than its BW capability in connected mode. While it is true that some early 5G deployment uses single BW 100MHz for the whole system operation but we noticed that supporting narrower BWP has becoming more popular recently and the old gNB can be upgraded to support this. In order to support redcap Ues, the gNB has to be upgraded anyway, we do not see the reason why a gNB supporting redcap Ues has the difficulty to upgrade to support a narrow BWP according to its capability. More importantly, it seems not reasonable to push all the burden (e.g. support larger BWP than its capability with potential fast BW switching) to a reduced capability device while the NW node stick to its old fashion of operation. We think the implementation burden should be shared somehow between NW and UE side for a successful eco-system] |
| Huawei |  | While our understanding of inter-BWP frequency hopping can still be hopping with an offset either larger than max RedCap UE bandwidth or narrower/within. |
| Samsung |  | We like to express our motivation to support UE operate in a wider BW or a faster BWP switching:   * Avoid fragmentation, as explain by Ericsson. We had been there to optimize PUSCH resource allocation of eMTC, due to define of narrowband. Now we are facing the same situation here, i.e., how a narrow band UE operate in a wide band system. We’d like to have a chance to provide a better design from the begining. * Improve spectial efficiency/capacity. BW reduced will lead the lose of scheduling gain, with a UE can be scheduled in full band, the degragation can be avoid. * More choice to gNB and UE: we try to avoid to support the Redcap UE with mandatory support of some features, (e.g., multiple BWP), and gNB has to deploy multiple BWP to serve Redcap Ues. On the other hand, we like to design a system can provide better performace and easy to be updated in the future.   Therefore, we think, at least study wider band operation and faster switching, (even multiple iBWP for offloading, although this may not be the focus in some companies view) is helpful. The scope of WI it to support RedCap, to ensure coexistence with legacy Ues, to provide a better performance (of course, we will balance all the aspects). At the first meeting of this WI, we think it should be OK to list the solutions/directions to worth to be studied. If wider BWP is something might be helpful, at least believed by some companies, we don’t see an issue to explicated list it there.  We prefer our original editor. If based on the proposal in FL7, we propose the following changes:   * For non-initial BWPs for RedCap Ues:   + ~~FFS: Whether to support RedCap UE operation in a BWP wider than the RedCap UE bandwidth~~   + FFS: Whether to support inter-BWP frequency hopping ~~mechanisms~~ for frequency diversity and/or scheduling gain     - FFS on faster switching assuming same numerology of mulitiple BWPs based on RAN 4’s feedback ~~if RedCap Ues operate on BWP not wider than the RedCap UE bandwidth~~   + FFS: Whether and how to avoid or reduce fragmentation of PUSCH resources for non-RedCap Ues, at least including to support Redcap UE operation by in a wider BWP than the RedCap UE bandwith   + FFS: Whether and how to support SSB and CORESET#0 having a combined bandwidth larger than the RedCap UE bandwidth in FR2   + FFS: Whether and how to support BWP#0 configuration option 2 supporting a single BWP in the cell |
| ZTE | N | For inter-BWP frequency hopping, we don’t think it is a necessary optimization. 20MHz already provide enough diversity gain and inter-BWP frequency hopping increases UE implementation complexity and UE power consumption.  Regarding ‘avoid or reduce fragmentation of PUSCH resources for non-RedCap Ues, enhancement in RedCap cannot resolve the ‘PUSCH fragmentation’ issue of non-RedCap Ues.  Regarding “Whether and how to support SSB and CORESET#0 having a combined bandwidth larger than the RedCap UE bandwidth in FR2”, not sure why non-initial BWPs need to consider this issue.  For “FFS: Whether and how to support BWP#0 configuration option 2 supporting a single BWP in the cell”, is this issue for shared BWP case? If yes, it can be resolved by configuring dedicated initial BWP for RedCap Ues. |
| OPPO | Y | Although it seems that some of the FFS are not so necessary, we can accept this proposal. |
| Spreadtrum |  | We have the following comments for each FFS   * For non-initial BWPs for RedCap Ues:   + ~~FFS: Whether to support RedCap UE operation in a BWP wider than the RedCap UE bandwidth~~   + FFS: Whether to support inter-BWP frequency hopping ~~mechanisms~~ for frequency diversity ~~if RedCap Ues operate on BWP not wider than the RedCap UE bandwidth~~   **[SPRD]:** We think hopping in a larger BW can be further studied, and the additional UE complexity of RF-retuning should be considered. Inter-BWP frequency hopping has several issues, e.g. potentially more BWPs, new BWP switching delay, new UE behavior to realize BWP based frequency hopping.   * + FFS: Whether and how to avoid or reduce fragmentation of PUSCH resources for non-RedCap Ues   **[SPRD]:** It is up to gNB implementation.   * + FFS: Whether and how to support SSB and CORESET#0 having a combined bandwidth larger than the RedCap UE bandwidth in FR2   **[SPRD]:** This is a UE capability in Rel.15   * + FFS: Whether and how to support BWP#0 configuration option 2 supporting a single BWP in the cell   **[SPRD]:** For DL BWP 0, it  can be restricted within the RedCap Max BW. The following restriction is unnecessary for RedCap UE: “In case of TDD, a BWP-pair (UL BWP and DL BWP with the same bwp-Id) must have the same center frequency (see TS 38.213, clause 12)”, if RF-returning is supported by RedCap UE for UL BWP. |
| Sharp | Y | For the last FFS, from our perspective, the single BWP under the BWP#0 configuration option 2 in the cell is still an RRC-configured initial BWP#0. It should not be a non-initial BWP. While the main bullet of the proposal is for the non-initial BWP for RedCap UE. Therefore, if the single BWP is intended for an initial BWP, previous agreements has already included an FFS regarding whether to allow a RedCap UE to operate with an initial BWP (during/after initial access) wider than the maximum RedCap UE bandwidth.  On the other hand, if the single BWP is intended for a non-initial BWP, ‘a single BWP in the cell’ itself seems confusing.  A bit more clarification is needed for the last FFS. |
| SONY | Y | We think it is useful to list some options for operation of non-initial BWPs, which is what this list of FFSs does.  We are also OK with the Samsung update on the second bullet. We thought their earlier text was better as it didn’t assume frequency hopping for providing diversity / scheduling / selectivity gains. If the system wanted a scheduling or selectivity gain, then it would seem that the UE should switch to a different frequency rather than hop between frequencies.   * + FFS: Whether to ~~support~~ enhance BWP switching including faster switching assuming same numerology of multiple BWPs based on RAN 4’s feedback ~~mechanisms~~ for frequency selectivity [and/or diversity] [and or scheduling] if RedCap Ues operate on BWP not wider than the RedCap UE bandwidth |
| CMCC | Y | We also think a reconfigured BWP larger than 20MHz is used only during the early phase of deployment, and when DCI based BWP switching is supported for devices, the motivation is smaller, as we commented for Question 2.2-4.  However, we can accept the proposal since all the options are FFS, and the last FFS will be clearer with CATT’s suggestion. |
| Nokia, NSB |  | We think that most of the issues listed here can already be addressed using R15/R16 specifications or via gNB implementation.  For inter-BWP hopping, we don’t really see meaningful increase in frequency diversity beyond what can already be achieved within RedCap UE BW.  For supporting a single BWP in a cell, we think there is no clear motivation to introduce RedCap operation in wider BW considering that the specifications already support multiple BWPs to handle this issue. Doing so would introduce another solution in the specifications, and can increase the complexity of RedCap feature substantially. |
| NordicSemi | Y | We are fine to have all FFS. With respect to the last one, dropping BWP Option 2 could potentially simplify operation, but for that consensus would be needed, since spec currently support both Option 1 and Option 2. |
| InterDigital | Y | We support studying the FFS points. |
| FUTUREWEI7 | N | Some of these FFS overlap with discussion that will occur for the initial BWPs, we should resolve there first before discussing non-initial BWPs. This is especially true for the last FFS proposed by Ericsson and added to FL7. Most of the FFS not an issue with proper configuration or implementation. The FFS on FH is probably in the most acceptable shape, but even that could be influenced by the investigation of the option for proper RF retuning. |
| Ericsson |  | We are okay with CATT’s suggested revision as well.  We appreciate Vivo’s comment on the last FFS bullet of Proposal 2.5-1c. We agree with most of the points in Vivo’s comment. We do expect most of the networks that today only support a single BWP in the cell to be upgraded to more advanced BWP capabilities when RedCap is commercialized. However, we cannot be sure every such network will take such a path. For now, we would like to keep this FFS so that we can assess the potential risk level more carefully. |
| FL8 Medium  FL9 |  | Based on the received responses, the following proposal can be considered.  Note that the all aspects of the proposal are just FFS. Agreeing to this proposal does not imply that any of the listed aspects are agreed to be supported, nor does it imply that aspects that are not listed are agreed to not be supported.  **Medium Priority Proposal 2.5-1d:**   * For non-initial BWPs for RedCap Ues:   + FFS: Whether and how to support RedCap UE operation in a BWP wider than the RedCap UE bandwidth   + FFS: Whether and how to support ~~inter-BWP frequency hopping~~ mechanisms for frequency diversity and/or scheduling gain ~~if RedCap Ues operate on BWP not wider than the RedCap UE bandwidth~~   + FFS: Whether and how to avoid or reduce fragmentation of PUSCH resources for non-RedCap Ues   + FFS: Whether and how to support BWP operation without restriction when SSB and CORESET#0 ~~having~~ have a combined bandwidth larger than the RedCap UE bandwidth in FR2   + FFS: Whether and how to support BWP#0 configuration option 2 supporting a single BWP in the cell, where the BWP is larger than RedCap UE bandwidth |
| Huawei | Y |  |
| NEC | Y |  |
| TCL | Y |  |
| China Telecom | Y | We are fine to list all FFSs in the proposal. |
| Qualcomm |  | * We think this proposal has lower priority than 2.2.4-f. * After RedCap UE established RRC connection with gNB, gNB can re-use the existing solutions of R15/16 to tackle the issues in 2nd and 3rd FFS bullet. * As commented by Nokia, ZTE and Vivo, we think companies supporting inter-BWP frequency hopping should show the sim results to justify the necessity/benefits, considering the non-trivial spec impacts of new BWP operation in RAN1 and RAN2. |

The draft LS (related to Section 6 in this document) in R1-2102094 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Inbox/R1-2102094.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2102094.zip)) was approved in an online (GTW) session on Wednesday 3rd February, but it was agreed that it may be updated with additional RAN4 related aspects for RedCap if needed.

**FL9 High Priority Question 2.5-2: What (if any) additional RAN4 related aspects do you think should be brought up in the LS to RAN4?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Qualcomm | Inter-BWP frequency hopping and fast BWP retuning have non-trivial spec impacts in RAN1 and RAN2.  Before RAN1 agrees on the necessity/benefits of inter-BWP frequency hopping and fast RF retuning for BWP, it is not necessary to send additional LS to RAN4. |
|  |  |
|  |  |

# Reduced minimum number of Rx branches

The WID [29] has the following objective on reduced minimum number of Rx branches:

|  |
| --- |
| * Reduced minimum number of Rx branches:   + For frequency bands where a legacy NR UE is required to be equipped with a minimum of 2 Rx antenna ports, the minimum number of Rx branches supported by specification for a RedCap UE is 1. The specification also supports 2 Rx branches for a RedCap UE in these bands.   + For frequency bands where a legacy NR UE (other than 2-Rx vehicular UE) is required to be equipped with a minimum of 4 Rx antenna ports, the minimum number of Rx branches supported by specification for a RedCap UE will be decided at RAN#91e; hence no specific work for these frequency bands will be done before RAN#91e. |

Based on the proposals in FL summary #3 in [R1-2101851](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101851.zip), the following RAN1 agreements were made in an online (GTW) session on Wednesday 3rd February:

|  |
| --- |
| Agreements:   * For reduced minimum number of Rx branches in FR1 and FR2 frequency bands where a legacy NR UE is required to be equipped with a minimum of 2 Rx antenna ports:   + FFS: need for solutions to reduced PDCCH blocking   + FFS: need for reporting of UE antenna related information to gNB (e.g., # of panels, polarization, etc.)   + Information related to the reduction of the number of antenna branches is assumed to be known at the gNB (either implicitly or explicitly, to be FFS) |

# Maximum number of DL MIMO layers

The WID [29] has the following objective on relaxed maximum number of DL MIMO layers:

|  |
| --- |
| * Maximum number of DL MIMO layers:   + For a RedCap UE with 1 Rx branch, 1 DL MIMO layer is supported.   + For a RedCap UE with 2 Rx branches, 2 DL MIMO layers are supported. |

Based on the proposals in FL summary #2 in [R1-2101850](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101850.zip), the following RAN1 agreements were made on the RAN1 reflector:

|  |
| --- |
| Agreements:   * For relaxed maximum number of DL MIMO layers:   + FFS: need for modification of DCI fields/formats   + FFS: need for modification of CSI measurement/reporting |

# Relaxed maximum modulation order

The WID [29] has the following objective on relaxed maximum modulation order:

|  |
| --- |
| * Relaxed maximum modulation order:   + Support of 256QAM in DL is optional (instead of mandatory) for an FR1 RedCap UE.   + No other relaxations of maximum modulation order are specified for a RedCap UE. |

Based on the proposals in FL summary #3 in [R1-2101851](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101851.zip), the following RAN1 agreements were made in an online (GTW) session on Wednesday 3rd February:

|  |
| --- |
| Agreements:   * The MCS tables currently defined are re-used for RedCap UEs   + FFS which MCS table is the default one for RedCap (i.e., the default one for non-RedCap UEs or the one with low SE entries)   + FFS mandatory/optional of the MCS tables   + Note: there is no new MCS table to be introduced for RedCap UEs |

**FL9 Low Priority Question 5.2: Can the CQI tables currently defined be re-used for RedCap UEs?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Huawei | Y | And no new CQI tables to be introduced for R17 RedCap. |
| NEC | Y |  |
| China Telecom | Y |  |
| Qualcomm | Y | It is not necessary to introduce new CQI table for R17 RedCap UE. |

# Duplex operation

The WID [29] has the following objective on relaxed maximum modulation order:

|  |
| --- |
| * Duplex operation:   + HD-FDD type A with the minimum specification impact (Note that FD-FDD and TDD are also supported.) |

From the submitted contributions, two main specification impacts have been identified, namely, the DL-to-UL and UL-to-DL switching time and the UE behaviour in handling DL/UL collision.

Based on the proposals in FL summary #2 in [R1-2101850](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101850.zip), the following RAN1 agreements were made in an online (GTW) session on Monday 1st February:

|  |
| --- |
| Agreements:   * For HD-FDD, for cases (if any) where collision handling needs to be specified, then the existing collision handling principles in Rel-15/16 NR for operation on a single carrier /single cell in unpaired spectrum are used as a starting point if deemed applicable.   Agreements:   * (Working assumption) For HD-FDD switching time, reuse existing switching times for UE not capable of full duplex in TS 38.211, Table 4.3.2-3.   + FFS: whether to define the guard times in symbol units   + FFS: the switching positions * Sending an LS to RAN4 to inform the above working assumption, and to ask for feedback if any   + The LS will not include the two FFS bullets |

The draft LS in R1-2102094 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Inbox/R1-2102094.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2102094.zip)) was approved in an online (GTW) session on Wednesday 3rd February, but it was agreed that it may be updated with additional RAN4 related information for RedCap if needed (see Section 2.5).

Based on the proposals in FL summary #3 in [R1-2101851](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101851.zip), the following RAN1 agreements were made in an online (GTW) session on Wednesday 3rd February:

|  |
| --- |
| Agreements:   * For HD-FDD operation for RedCap UEs, collisions may be addressed or alleviated with proper scheduling. The following cases of potential collisions can be further studied to see if any change to the current specs is necessary:   + Case 1: Dynamically scheduled DL reception vs. semi-statically configured UL transmission     - e.g., dynamic PDSCH or CSI-RS collides with configured SRS, PUCCH, or CG PUSCH   + Case 2: Semi-statically configured DL reception vs. dynamically scheduled UL transmission     - e.g., PDCCH or SPS PDSCH collides with dynamic PUSCH or PUCCH   + Case 3: Semi-statically configured DL reception vs. semi-statically configured UL transmission   + Case 4: Dynamically scheduled DL reception vs. dynamic scheduled UL transmission   + Case 5: Configured SSB vs. dynamically scheduled or configured UL transmission     - e.g., PUSCH, PUCCH, PRACH, SRS   + Case 8: Dynamic or semi-static DL vs. valid RO   + Case 9: Collision due to direction switching |

# Other aspects (for information)

**General aspects**

* [1] Avoid over-optimization for small benefits
* [1] In Rel-17, no need to introduce enhancements for high RedCap connection density scenarios
* [12] In principle, the network shall not restrict the configurations for the legacy UEs in order to guarantee the RedCap UE performance.
* [12] The performance degradation of legacy UEs due to the introduced vast RedCap UEs shall be reduced through e.g., access control, separate initial BWP for RedCap UEs, etc.
* [9] For RedCap UEs in FR1, there is no issue if the UEs do not achieve 150 Mbps.

**UE type definition**

A few contributions express views on UE type definition. Since UE type definition is still under study in RAN2, the FL suggests coming back to this discussion in a later RAN1 meeting.

* [10] Further study explicit definition of RedCap UE type(s) for RedCap UE identification between option 2 and 4
* [12]: If 1Rx branch is to be supported for FR1 TDD bands where a non-RedCap UE is required to be equipped with a minimum of 4 Rx branches, two RedCap UE types are to be defined, one with 1Rx and the other with 2Rx.
* [9] Economies of scale can drive the cost reduction for RedCap UE modems. Device types should be defined so as not to fragment the UE modem market. Evolution of a single market segment (e.g. wearables) may play an essential role in enabling other markets across all application scenarios through economies of scale for RedCap UE modems.

**System information transmissions**

A few contributions express views on system information transmission. Some of these contributions mention SIB1 specifically, whereas some contributions imply system information in general.

* [1] Avoid duplication of existing system information in new SIBs intended specifically for RedCap UEs
* [1] RedCap-specific information may be conveyed using the following options: 1) reusing the existing SIBs and defining new information elements in one of the existing SI blocks, or 2) introducing separate SIBs (i.e., new SI blocks for RedCap).
* [22] In FR1, NR RedCap UE and non-RedCap UE should share the same SIB1. Other SIBs for RedCap UE can be scheduled by SIB1 or transmitted on-demand within the initial BWP of RedCap UE.
* [19] In FR1, there is no impact on the reception of RMSI when the maximum UE bandwidth is 20MHz
* [7] Reuse Rel-15 SIB1 design for RedCap UEs.
* [4] Consider supporting configurability of using legacy SIB1 (possibly with RedCap specific IEs) or defining RedCap specific SIB1.
* [13] Consider supporting at least one of following alternatives:
  + New field in SIB1 for RedCap UE
  + New SIBX dedicated for RedCap UE

For SIB transmissions, the following approaches can be identified:

1. RedCap UEs and non-RedCap UEs share the same SIBs with SIBs extended to include RedCap specific IEs.
2. RedCap UEs and non-RedCap UEs share the same legacy SIBs. New SIBs are introduced to convey additional system information intended for RedCap UEs.
3. New SIBs are introduced to convey all system information needed for supporting RedCap UEs. RedCap UEs are not required to read the legacy SIBs.

**Initial access and paging**

Few contributions have expressed views on paging and other aspects related to the initial access procedure (which are not covered in the previous sections).

* [4] FFS configuration separation (of Redcap UEs and non-RedCap UEs) for paging or RAR specific to RedCap.
* [8] In Idle mode, dedicated paging occasions are considered for RedCap UEs.
* [20] Separated configuration for initial access and paging (for Redcap UEs from non-RedCap UEs) can be supported.

**Early indication**

Several contributions [3, 2, 7, 8, 10, 11, 13, 16, 18, 22] have expressed views on the need for early indication of RedCap UEs, e.g., in Msg1 and/or Msg3. With regards to Msg1 indication in specific, most of these contributions have highlighted the importance of Msg1 indication (e.g., for coverage recovery, when initial UL BWP greater than UE BW, etc.). Some of these contributions have also mentioned that the use of early indication can be configurable by the NW based on, for e.g., NW deployment, coverage recovery needs, configuration of initial UL BWP, etc.

**PDCCH search spaces and blocking**

A few contributions discuss techniques for reducing PDCCH blocking rate in coexistence of RedCap and legacy UEs. Some contributions have brought up solutions to solve the potential PDCCH blocking issue when the CORESET for RedCap UEs are shared/overlapped with that of non-RedCap UEs.

* [1] Strive to have CORESET designs that achieve efficient resource utilization.
* [4] FFS configuration separation for Paging or RAR specific to RedCap.
* [19] Consider extending the CORESET duration in time domain to enhance the CORESET capacity. Reuse the existing mapping design of REG bundle, CCE and PDCCH as much as possible.
* [20] Further study on allowing the DL resource outside of CORESET 0 for at least Type1-PDCCH CSS, Type 2-PDCCH CSS, and the scheduled PDSCH.
* [20] Support multi-PDSCHs/PUSCHs scheduling for PDCCH overhead reduction and PDCCH blocking rate reduction.
* [24] Consider whether to separate Type 1 CSS configuration for RedCap UEs in SIB1 to address some congestions.
* [25] Support compact DCI with potential further DCI reduction (than Rel-16 URLLC) for RedCap UEs.

**DCI definition**

A few contributions express general views on DCI design.

* [1] Reuse existing formats as much as possible avoiding minor optimizations aiming at saving a few bits
* [4] Consider supporting PDCCH enhancements from the perspective of PDCCH capacity and efficiency improvement, e.g. a compact DCI or a group-wise DCI.
* [24] Compared to the design of DCI formats 0\_1/1\_1, the design of DCI formats 0\_2/1\_2 can better adapt to characteristics of various RedCap use cases requirements, given the design of DCI formats 1\_2/0\_2 is of full flexibility with much more configurable DCI fields sizes.
* [25] Support compact DCI with potential further DCI size reduction for RedCap UEs.

The FL suggests down-prioritizing DCI format discussion until the open issues regarding minimum number of Rx branches and optional support of a wider bandwidth up to 40MHz after initial access in FR1 are further discussed at RAN#91e.

**TBS restriction**

* [13] TBS restriction should be considered for RedCap UE (to facilitate further complexity reduction).

**CSI reporting**

In addition, contribution [20] suggests CSI report enhancements for RedCap:

* [20] FFS CSI report for a wider BWP bandwidth, including PDCCH based CSI report (for RedCap UEs operating in a BWP larger than its UE bandwidth).
* [20] FFS support of SRS transmissions or CSI report for link adaptation outside active BWP (for RedCap UEs with UE-specific BWP no larger than its UE bandwidth).
* [20] Consider supporting SB CSI reporting for BWP size < 24 PRBs, at least for RedCap UEs:
  + Support a SB size for BWP size < 24 PRBs, where the SB size can be fixed or configured
  + When BWP size < 24 PRBs, the SB CSI reporting can be restricted to rank 1 only and a small number of CSI-RS ports (e.g. 2 or 4)

**Coverage related issues**

* [3] Consider specifying large PDCCH AL or PDCCH repetition for coverage recovery for Redcap UE with 1 Rx.
* [18] SUL can be considered as optional capability to meet high data rate requirement, SUL has additional benefit of improving uplink coverage
* [22] In FR1, SUL is not supported by NR RedCap UE. Coverage recovery on NUL can re-use at least the solutions provided by R-17 CE WI.

**Power saving solutions**

* [3] MIMO layer adaptation as specified in Rel-16 power saving shall be supported for a RedCap UE with 2 Rx branches.
* [10] RedCap UE with two Rx supports maximum one layer in DL if MIMO layer adaptation for power saving would be expected useful for the RedCap UE.
* [10] Semi-static adoption of power saving feature within active BWP.
* [18] BWP switching based on DCI, RRC and timer is supported to facilitate power saving.
* [22] For FR2, to save UE power and complexity, consider switching the UE to a narrow active BWP (NBWP) after initial access is complete. The switching may be network initiated/controlled, implicit, or UE initiated/requested.

# References

|  |  |  |  |
| --- | --- | --- | --- |
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| [3] | [R1-2101777](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101777.zip) | Discussion on UE complexity reduction (revision of [R1-2100165](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100165.zip)) | OPPO |
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| [5] | [R1-2100389](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100389.zip) | Discussion on UE complexity reduction features | CATT |
| [6] | [R1-2100449](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100449.zip) | Discussion on UE Complexity reduction | Vivo, Guangdong Genius |
| [7] | [R1-2100499](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100499.zip) | UE complexity reduction | Nokia, Nokia Shanghai Bell |
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| [14] | [R1-2100843](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100843.zip) | UE complexity reduction | Panasonic Corporation |
| [15] | [R1-2100865](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100865.zip) | UE complexity reduction for Redcap devices | Sony |
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