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 #3 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

The previous rounds of this email 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) and [R1-2101850](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101850.zip).

In this round of the discussion, companies are requested to provide comments before Tuesday 2nd February 21:00 UTC on the proposals and questions tagged FL6.

Follow the naming convention in this example:

* *RedCapFLS3-v000.docx*
* *RedCapFLS3-v001-CompanyA.docx*
* *RedCapFLS3-v002-CompanyA-CompanyB.docx*
* *RedCapFLS3-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 *RedCapFLS3-v002-CompanyA-CompanyB.docx*.
* CompanyC uploads an empty file named *RedCapFLS3-v003-CompanyB-CompanyC.checkout*
* CompanyC then has 30 minutes to upload *RedCapFLS3-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 |  | |

## 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?**

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| **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. |

# 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. |

Many contributions [1, 3, 4, 5, 6, 7, 11, 12, 16, 18, 19, 20, 21, 22, 23, 25, 28] express views on the minimum number of Rx branches for RedCap UEs operating in frequency bands where a legacy NR UE is required to be equipped with 4 Rx. According to WID, the related aspects to these frequency bands shall be discussed after RAN#91e.

Several contributions [1, 2, 3, 7, 8, 10, 11, 12, 13, 16] express views on RedCap UE type definition and early indication of UE type. This topic belongs more under agenda item 8.6.2 which will not be discussed in this meeting according to the agenda.

A few contributions [1, 2, 3, 4, 13] express views on coverage recovery solutions. According to the WID, the appropriate WI for handling of any potential coverage recovery aspects related to RedCap UEs devices will be considered at RAN#91e. Contribution [3] also suggests specifying a mechanism to handle antenna inefficiency. The WID currently does not include any explicit objective on antenna inefficiency.

Contribution [3] suggests that either the MCS table for NR normal coverage or the low spectral efficiency MCS table for PDSCH which does not have 256QAM entries is used for RedCap devices, or a new MCS table optimized for RedCap UEs is defined.

Regarding the specification impacts, some contributions [1, 5, 7] express that the impact on RAN1 specifications is limited, and some contributions [1, 3, 7, 10, 13] express that the impact on several aspects of RAN4 specifications should be evaluated (mainly related to RAN4 performance requirements, including demodulation performance, CSI reporting, RRM, cell handover or (re)selection, radio link management, beam management).

**High Priority Question 3-1: For FR1 and FR2 frequency bands where a legacy NR UE is required to be equipped with a minimum of 2 Rx antenna ports, what RAN1 specification impacts (beyond possible early UE type identification and possible coverage recovery related functionality) do you expect from reduced minimum number of Rx branches for RedCap devices?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Comments** | |
| Qualcomm | We don’t expect significant impacts on RAN1 except for:   1. early UE type indication discussed in Section 2.3 of this document 2. possible coverage recovery related functionality to compensate for reduced antenna efficiency 3. for FR2, UE antenna configuration (polarization/panels) report to the gNB | |
| DOCOMO | We think some solution for reducing PDCCH blocking rate should be discussed in coexistence of RedCap and legacy UEs, as higher AL would be necessary for RedCap UEs due to reduced number of Rx antenna ports, which results in increased PDCCH blocking rate | |
| Ericsson | None. | |
| Nokia, NSB | None | |
| TCL | We prefer to discuss PDCCH repetition, because coverage recovery is required for RedCap UEs due to the reduction in the number of Rx antenna ports. We also agree with the DOCOMO comment. | |
| ZTE | None | |
| CMCC | None. | |
| China Telecom | None. | |
| Intel | None beyond the potential ones already mentioned in the question. | |
| CATT | None | |
| Sharp | None. | |
| Vivo | None. And there is no need to support early identification due to Reduced Rx | |
| NEC | None. | |
| Huawei | The applicability of existing features/R17 CE WI techniques for RedCap UEs require some discussion. | |
| Xiaomi | Same view with DOCOMO | |
| Samsung | We think PDCCH blocking rate, PDCCH overhead need to be addressed. | |
| Panasonic | None | |
| LG | None beyond what FL mentioned (possible early UE type identification and possible coverage recovery related functionality). | |
| OPPO | Possible coverage recovery related functionality to compensate for reduced antenna gain loss, e.g., for wearbles. | |
| InterDigital | None. | |
| Lenovo, Motorola Mobility | None | |
| FUTUREWEI | No significant impacts except for early identification and possible coverage recovery enhancements | |
| SONY | Agree with Qualcomm that for FR2, UE antenna configuration (polarization/panels) may need to be reported to the gNB.  Agree with the baseline proposal (possible early identification and possible coverage recovery) | |
| APT | None | |
| Apple | None. | |
| MediaTek | None | |
| FL1 | Based on the received responses, the following proposal can be considered. Possible early UE type identification and possible coverage recovery related functionality are not captured in the proposal since these aspects are pending further RAN plenary decisions in RAN#91e.  **High Priority Proposal 3.1a:**   * 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 and/or overhead   + FFS: need for UE antenna configuration reporting to gNB in FR2 | |
| Qualcomm | We are ok with FL1 proposal as above | |
| InterDigital | Y | |
| Intel | Y | |
| DOCOMO | We support FL1 proposal | |
| Nokia, NSB | Y | |
| vivo | The first FFS sub-bullet is beyond the current WID scope thus should not be included | |
| FUTUREWEI | We understand the intention of the second FFS given Qualcomm’s response, but as written it may imply that 1RX or 2RX itself does not need to be reported. So a small clarification may be needed. | |
| CATT | Is the first FFS sub-bullet reopening the enhancement on PDCCH monitoring reduction? | |
| OPPO | Y | |
| ZTE | Y | |
| LG | We are not okay with the proposal.  In our opinion, the two FFS points are much less motivated and supported by companies than the early UE type identification and coverage recovery related functionality. So, we don’t see the need to agree on the Proposal 3.1a with the only 2 FFS points. | |
| Xiaomi | Y | |
| TCL | Y | |
| NEC | Y | |
| CMCC | Y | |
| Lenovo, Motorola Mobility | Fine with FL’s proposal | |
| Samsung | OK. | |
| Sharp | Y | |
| China Unicom | Y | |
| Ericsson | We are fine with the proposal. | |
| Huawei, HiSi | Y | |
| **Company** | **Y/N** | **Comments** |
| FL2 |  | Based on the received responses, the following proposal can be considered. Possible early UE type identification and possible coverage recovery related functionality are not captured in the proposal since these aspects are pending further RAN plenary decisions in RAN#91e.  **High Priority Proposal 3.1b:**   * 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 and/or overhead   + FFS: need for UE antenna/branch configuration reporting to gNB |
| Qualcomm | Y |  |
| FUTUREWEI2 |  | We did not really get an answer to our question, is the FL intent that whether a UE is 1RX or 2RX does not need to ever be known by the gNB?  If we can’t word it properly also OK to wait till next meeting for this one when we have the full reduced RX picture. |
| Nokia, NSB | Y |  |
| FL |  | In response to Futurewei’s comment:  There is no FL intention to preclude gNB knowledge of the number of UE Rx branches. (Can an FFS really preclude anything?)  Note that the wording was updated in Proposal 3.1b compared to Proposals 3.1a to say “UE antenna/branch configuration” instead of “UE antenna configuration” as an attempt to address Futurewei’s concern. |
| Xiaomi | Y |  |
| Ericsson | Y |  |
| vivo | N | As commented before, the first FFS bullet is beyond the WID scope thus should be removed. |
| Intel | Y |  |
| LG | N | We are still not okay with this proposal. Nothing has changed.  Other than the possible early UE type identification and possible coverage recovery related functionality, we see the motivation of enhancement of the first FFS is too weak. Same for the second FFS which is not even clear what is intended. |
| APT | Y |  |
| FUTUREWEI2 |  | Thanks for the FL attempt to clarify. We thought the Qualcomm intent was the need for antenna configuration information beyond the number of RX branches. But the FL clarification still appears to leave reporting the number of branches up in the air. Perhaps the FL intent is to want RX branches to only be reported as part of early identification? Anyway, since the FFS is not clear and we have #RX clarifications at next RAN anyway, let us wait on that FFS. |
| NEC | Y |  |
| DOCOMO | Y | We fail to understand why the first FFS is out of WID scope or its motivation is too weak. As clearly stated in WID, coexistence with non-RedCap UEs is to be ensured. TR 38.875 captures following in Clause 7.2.4: Analysis of coexistence with legacy UEs for reduced number of Rx antenna ports.  If higher PDCCH aggregation levels are used for RedCap UEs, the PDCCH blocking rate for legacy UEs may be increased if they share the same CORESET.  Obviously, first FFS is not out of WID scope and should be addressed |
| China Telecom |  | We are fine to wait till the next RAN meeting to make the final decisions on the reduced minimum number of Rx branches. |
| CATT | Y | Maybe OK to further discuss whether the motivations are strong enough. |
| Samsung | Y |  |
| Sharp | Y |  |
| ZTE | Y |  |
| Lenovo, Motorola Mobility | Y |  |
| CMCC | Y |  |
| InterDigital | Y |  |
| MediaTek | Y | Fine with the proposal |
| FL3 |  | Based on the received responses, the following proposal can be considered. Possible early UE type identification and possible coverage recovery related functionality are not captured in the proposal since these aspects are pending further RAN plenary decisions in RAN#91e.  For the FFS on the potential need for solutions to reduced PDCCH blocking and/or overhead, different views were expressed in the responses. Two responses argue that it is not in the WI scope or that the motivation is too weak, whereas one response argue that the FFS is in the WI scope.  The FFS on the potential need for UE antenna/branch configuration reporting to gNB has been removed since some responses expressed that it is better treated after the WI objective on reduced minimum number of Rx branches has been further clarified in RAN#91e.  **High Priority Proposal 3.1c:**   * 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 and/or overhead |
| FUTUREWEI3 | Y |  |
| Nokia, NSB | Y |  |
| Qualcomm |  | Based on the WID for R17 RedCap devices, it is agreed that:  *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.*  Since RedCap UE with 1 RX or 2 RX branches will be supported on frequency bands where a legacy NR UE is required to be equipped with a minimum of 2 Rx antenna ports, it is necessary for gNB to differentiate them in the UE capability query/report after initial access.  Therefore, we support FL2 proposal as it is. |
| Intel | Y | Our understanding on reporting number of supported Rx branches can be discussed as part of UE features discussions at a later stage in the WI. |
| DOCOMO | Y |  |
| Huawei, HiSi | Y |  |
| Xiaomi | Y |  |
| LG |  | The proponent of the FFS part seems to assume that the performance of 1 Rx UE’s have some issues in coverage compared to 2 Rx UEs. This is related to RAN plenary discussion on the number of Rx for NR 4-Rx bands. From our perspective, this is not clear yet and in a use cases such as smart wearables, we are not sure if there is significant performance different to change the AL level. We still don’t see the motivation is strong.  And we think the “and/or overhead” in the FFS should be removed unless the intention of it is clear explained and understood. |
| Vivo |  | Regarding the “FFS: need for solutions to reduced PDCCH blocking and/or overhead”, we can understand DOCOMO’s argument. However, procedure wise, reduced PDCCH blocking was not captured in the WID so strictly speaking it is out of scope. For this particular case, we would be fine to keep the FFS if we are the only company who had concern, but we are worried if this would encourage other enhancements that are not explicitly mentioned in the WID (although they may have been discussed during SI phase without recommendation).  Regarding “FFS: need for UE antenna/branch configuration reporting to gNB”, we agree with Qualcomm and would like to keep it. |
| Ericsson | Y |  |
| OPPO |  | For a pure FFS proposal, we don’t see the necessity to agree on it.  We propose to firstly check whether the PDCCH blocking and/or overhead exists. |
| CATT | Y |  |
| TCL | Y |  |
| NEC | Y |  |
| Apple |  | Support to study solutions for PDCCH capacity enhancement for Redcap use cases. On the other hand, agreement with only FFS is less progress. |
| CMCC | Y |  |
| Sharp | Y |  |
| ZTE | Y |  |
| Panasonic | Y |  |
| Samsung | Y |  |
| Lenovo, Motorola Mobility | Y |  |
| SONY |  | As per Qualcomm, we prefer the FL2 proposal as is.  Our understanding about the “FFS: need for UE antenna/branch configuration reporting to gNB” in FL2 is that it is not just about the number of RX branches, but is also about the antenna configuration (polarisation / panels) in FR2. |
| FL5 High  FL6 |  | Most received responses are fine with the proposal, but a few responses want to remove the FFS on the need for solutions to reduce PDCCH blocking/overhead and/or add back the FFS on the need for UE antenna/branch configuration reporting to gNB.  Based on the received responses, the following proposal can be discussed again.  **High Priority Proposal 3.1b:**   * 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 and/or overhead   + FFS: need for UE antenna/branch configuration reporting to gNB |
| Qualcomm | Y |  |
| NEC | Y |  |
| CATT | Y |  |
| LG |  | We still don’t see a need for the first FFS. Especially in typical use cases such as smart wearables in FR1, it is not sure if there would be a significant performance difference between 1 Rx and 2Rx to change the AL level. This is somehow related to the RAN plenary discussion on the number of Rx branches for NR 4-Rx bands. If the first FFS mainly involves the performance differences b/w 1 Rx and 2 Rx, then it is already under discussion/study and we have to wait for a conclusion from that discussion. And we still think the “and/or overhead” in the FFS should be removed unless the intention of it is clear explained and understood.  For the second FFS, if it is meant for capability report after initial access, then it can be treated later together with other capabilities to be reported after initial access unless we want to make FFSs from the start for each of the capabilities to be reported after initial access. |
| Xiaomi | Y |  |
| vivo |  | As commented before, we believe the 1st FFS is beyond the WID scope and prefer to remove it. But we won’t object if companies has strong desire to study it. |
| DOCOMO | Y | We still prefer to keep 1st FFS because of the reason commented before. |
| TCL | Y |  |
| China Telecom | Y | We are fine to keep the first FFS which can be revisited after more discussion. |
| Intel | Y |  |
| Samsung | Y |  |

# 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. |

Several contributions express views on the specification impacts due to relaxed maximum DL modulation order in FR1. Most contributions [1, 2, 5, 7, 8, 20, 25] observe that no introduction of new or optimization of existing MCS tables, CQI tables and/or DCI are necessary for RedCap devices.

However, in contribution [2], it is proposed that the lower spectral efficiency table should be the default table when a UE does not support 256QAM and has on receive antenna. In contribution [5], it is suggested that the network can determine which MCS table and CQI table to use based on UE capability.

A few contributions [1, 7, 8, 25] indicate the UE capability signaling would be the main impact. Contributions [1, 8] further note that the existing parameter “*pdsch-256QAM-FR1*” may be re-used for RedCap devices.

In contribution [7], it is further noted that UE behavior is not defined when there is scheduling error for using 256QAM.

**High Priority Question 5-1: What RAN1 specification impacts (beyond UE capability signalling) do you expect from relaxed maximum DL modulation order in FR1 for RedCap devices?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Comments** | |
| Qualcomm | For relaxed max DL modulation order, we don’t expect significant impacts in FR1, except for supporting low-SE MCS table of NR R15 during initial access of RedCap devices. | |
| DOCOMO | No critical specification impacts are seen so far | |
| Ericsson | None | |
| Nokia, NSB | None | |
| TCL | None | |
| ZTE | None | |
| CMCC | None. | |
| China Telecom | None. | |
| Intel | None. | |
| CATT | None | |
| Sharp | None. | |
| Vivo | None | |
| NEC | None | |
| Huawei | None. Low-SE MCS can be an optional UE feature as legacy UEs. | |
| Xiaomi | No critic specification impact. But we are open to discuss whether support the lower-SE MCS table | |
| Samsung | None | |
| Panasonic | None | |
| Spreadtrum | None | |
| LG | None | |
| OPPO | None | |
| InterDigital | None. | |
| Lenovo, Motorola Mobility | None | |
| FUTUREWEI | Similar views as Qualcomm | |
| SONY | None | |
| APT | None | |
| Apple | None | |
| FL1 | Based on the received responses, the following proposal can be considered.  **High Priority Proposal 5.1a:**   * For relaxed maximum modulation order:   + FFS: support/applicability of the lower-SE MCS table in 38.214 during initial access | |
| Qualcomm | We are ok with FL1 proposal as above | |
| InterDigital | Y | |
| Intel | Y | |
| China Telecom | Y | |
| DOCOMO | We are fine with FL1 proposal | |
| Nokia, NSB | Y | |
| vivo | We are not sure about the FFS bullet. Our understanding is that lower-SE MCS table cannot be used for legacy UEs during initial access (has to be configured after initial access). | |
| FUTUREWEI | Y | |
| CATT | OK for us. | |
| OPPO | Y | |
| ZTE | Y | |
| LG | Okay. But don’t see a need to have this agreement with the minor, if any, enhancement only. | |
| Xiaomi | Do we need to limit the use case of lower-SE MCS table in initial access? We think the lower-SE MCS table can be used after initial access as well. | |
| TCL | Y | |
| NEC | Y | |
| CMCC | Y | |
| Lenovo, Motorola Mobility | Fine with FL’s proposal | |
| Samsung | We don’t see the need to support low SE MCS table.  We think a conclusion to conclude is more proper, such as:  **Current RAN 1 spec can support relaxed maximum DL modulation order in FR1 for RedCap devices.** | |
| Sharp | Y | |
| China Unicom | Y | |
| Ericsson | We are fine with the proposal. | |
| Huawei, HiSi | N.  The current FFS in the proposal has nothing to do with spec impact due to relaxed modulation order (from mandatory 256QAM to 64QAM). In our view it is about to extend some existing features supported by legacy UEs as optional after initial access to RedCap UEs during initial access, for coverage purpose. We suggest to discuss all coverage related proposals and its relationship with existing features/R17 CE WI features at a proper place/timing. | |
| **Company** | **Y/N** | **Comments** |
| FL2 |  | As commented by Huawei, possible coverage recovery related functionality is not expected to be discussed in this meeting since this aspect is pending further RAN plenary decisions in RAN#91e. Instead, the following potential conclusion proposed by Samsung can be considered.  **High Priority Proposal 5.1b:**   * Conclusion: Current RAN1 specifications can support relaxed maximum DL modulation order in FR1 for RedCap devices. |
| Qualcomm |  | We don’t think this conclusion is necessary. This is clear from the WID already. |
| FUTUREWEI2 | N | We are OK to wait to discuss. The modulation tables for RedCap need to be discussed, and this is an example of a feature beneficial to RedCap UEs that is currently optional that should probably be mandatory. As Qualcomm mentioned, it could also be tied to initial access. The picture for early identification and 1RX will be more clear after next RAN. |
| Nokia, NSB | Y | We are fine to have the conclusion |
| Xiaomi |  | OK to discuss the application of lower-SE MCS table in latter phase.  But at current stage, since the MCS table to be used during and after initial access is not agreed, so we don’t need to rush to get a conclusion. We could further discuss the MCS table to be used for Redcap based on the possible conclusion of 1Rx or coverage recovery to be made during next RANP meeting. |
| Ericsson | Y |  |
| vivo | Y |  |
| Intel | Y |  |
| LG | Y | We are supportive of having this type of conclusion for clarification especially for RedCap. We would like to note that this is not in the scope of the reduced DL modulation order. This is more related to coverage recovery thing which we don’t have to discuss under this feature. We are okay to not agreeing on anything related to this issue in this sense. |
| APT | Y | We are fine with the conclusion. |
| OPPO | Y |  |
| NEC | Y |  |
| DOCOMO | Y |  |
| China Telecom | Y | We are fine to have this conclusion if it is needed. |
| CATT | Y |  |
| Samsung | Y | We prefer a conclusion. The conclusion has more information than WID, i.e., no spec change is needed to support this feature. |
| Sharp | Y |  |
| ZTE |  | We don’t think this conclusion is necessary. |
| Huawei, HiSi | N | This conclusion does not seem to help the progress. As several companies mentioned the original proposal relates to coverage and somewhat the intention of the original proposal is not relevant to modulation order relaxation. On top of that, we think a more general discussion/understanding may be needed, like whether all existing optional features are be default applicable to RedCap UEs unless specifically issues are identified, which can be discussed case by case.  For the discussion comes to the applicability of initial access, it even requires more attention since early identification may be needed – too many dimensions for identification may not be desirable.  Given no benefits that the proposed conclusion can offer and we will anyway discuss other optional features, we prefer not to discuss this. (and by default, if no issue identified to the end of the WI, it could be the case as proposed). |
| Lenovo, Motorola Mobility | Y |  |
| CMCC | Y |  |
| InterDigital | Y |  |
| MediaTek | Y |  |
| FL3 |  | Based on the received responses, the following proposal can be considered.  **High Priority Proposal 5.1c:**   * For relaxed maximum modulation order:   + FFS: which one of the currently defined MCS tables that is the default MCS table for RedCap UEs not supporting 256QAM |
| FUTUREWEI3 | Y | Also OK to wait to discuss |
| Nokia, NSB |  | We are not quite sure why this FFS is considered under relaxed maximum modulation order. In our view the issue of default MCS table is related to coverage recovery and is not dependent on whether UE supports 256-QAM or not.  So we think the previous proposal 5.1b is good and this proposal is not really relevant to relaxed maximum modulation order. |
| Qualcomm | Y | An editorial suggestion for the FFS part:  o FFS: which one of the currently defined MCS tables ~~that~~ is the default MCS table for RedCap UEs not supporting 256QAM |
| Intel | Y |  |
| DOCOMO | Y | OK to further discuss FFS part, but should be postponed to discuss until next meeting as it is related to coverage perspective. |
| Huawei, HiSi | N | The alt does not change the reasons for NOT support: there is no issue for the current default tables to be used, due to relax of DL modulation order. So it is irrelevant. |
| Xiaomi | N | It seems there is no relationship between the default MCS table configuration and the support of 256 QAM. Even for UE supporting 256 QAM, how to define the default MCS table is also one issue to be discussed.  We are OK to discuss this issue in next meeting when the situation of coverage recovery is stable and clear. |
| LG |  | We also prefer the previous one, Proposal 5.1b. |
| vivo | Y | We are fine with the latest proposal above |
| Ericsson | Y | We will also be fine to wait. |
| OPPO | Y | We are fine to discuss this issue till next meeting when the coverage recovery is clear. |
| CATT | Y |  |
| TCL | Y |  |
| NEC | Y |  |
| CMCC | Y |  |
| Sharp | Y |  |
| ZTE | Y |  |
| Panasonic | Y |  |
| Samsung |  | We prefer the original proposal 5.1b. The MCS table defined in current spec has no issue. |
| Spreadtrum | Y |  |
| Lenovo, Motorola Mobility |  | We prefer the original proposal 5.1b. |
| SONY |  | Agree with Nokia-NSB that this proposal is about coverage recovery rather than reduced maximum modulation order. We don’t have a strong objection to the proposal so haven’t written “N” in the “agree / disagree” column. |
| FL5 High  FL6 |  | Some received responses noted that the MCS table might need to be discussed also for the case when the RedCap UE supports 256QAM. Based on the received responses, the following proposal can be considered.  **High Priority Proposal 5.1d:**   * FFS: which one(s) of the currently defined MCS tables is/are the default MCS table(s) for RedCap UEs supporting and not supporting 256QAM, respectively |
| Qualcomm | Y |  |
| NEC | Y |  |
| CATT | Y |  |
| LG |  | We prefer the Proposal 5.1b as a conclusion on the reduced maximum DL modulation order.  For the optional support of Low-SE MCS table, we don’t see it is needed, but it can be discussed later when we discuss which features from the legacy UEs are supported for RedCap UEs. No need to discuss this in the context of reduced maximum DL modulation order. |
| Xiaomi | Y |  |
| vivo | Y |  |
| DOCOMO | Y |  |
| TCL | Y |  |
| China Telecom | Y |  |
| Intel | Y |  |
| Samsung |  | We can live with the following modified FFS together with the conclusion.  Conclusion: Current RAN1 specifications can support relaxed maximum DL modulation order in FR1 for RedCap devices.  FFS: whether any ~~which one(s) of the~~ currently defined MCS tables other than ~~is/are~~ the current default MCS table~~(s)~~ is needed for RedCap UEs supporting and not supporting 256QAM, respectively. |

# 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 |

Regarding how HD-FDD Type-A UE handles DL/UL collision, several contributions have expressed their views. Contributions [1, 7, 8, 11, 12, 18, 19, 23] mentioned that in general, collision may be avoided by the scheduler. However, several contributions [1, 2, 6, 7, 13, 19, 20] also noted that DL/UL collision may not be avoidable in some scenarios and would be handled by UE.

Several contributions have expressed their views on how UE should handle potential collision cases. For example, contributions [1, 2, 5] proposed to reuse the same definition for UE behavior as defined for UE not capable of full duplex communication in TS 38.211. Contributions [6, 8, 20, 19, 25] proposed to reuse the existing rules defined for TDD in TS 38.213 (Section 11.1). Other mentioned solutions include using LTE/LTE-M approach [3, 12, 18] or having some signal/channel-specific prioritization rule such as PUCCH, PUSCH, aperiodic SRS > PDCCH, P/SP-CSI-RS > P/SP-SRS [21].

It was also mentioned by some contributions [1, 6, 7, 14, 16] that special attention may be needed when it comes to collision between dynamic and configured transmission/reception. For example, contributions [1, 6, 7, 14, 19, 20] mentioned that dynamic scheduling should be prioritized over semi-static configured transmission/reception.

As a starting point, it would be good to identify relevant DL/UL collision cases now and discuss potential solutions at a later stage. In general, there can be different collision scenarios between DL reception and UL transmission which may be categorized as follows:

* **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. UL transmission
  + e.g., PUSCH, PUCCH, PRACH, SRS

**Medium Priority Question 6-2: Is the list of DL/UL collision cases above complete in your view? If not, what other collision cases should be considered for RedCap UE?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | Y |  |
| TCL | Y | A potential collision may happen when BWP switch and HD-FDD D-U switch performed successively but the time gap is not long enough to complete the previous switch. |
| Vivo | Y | The listed 5 cases can be discussed as starting point. |
| Panasonic | Y |  |
| Spreadtrum | Y |  |
| SONY | N | Case 6: monitoring for UL cancellation indication while transmitting in UL.  For FD-FDD, a low priority UL transmission can be cancelled by the gNB sending in a UL cancellation indication in the DL. Some similar functionality should also be supported for HD-FDD.  The 5 listed cases in the FL proposal also need to be considered. |
| ZTE | Y | The listed 5 cases can be as starting point. But not preclude other collision cases if identified. |
| CMCC | Y |  |
| Samsung | Y |  |
| Sharp | Y |  |
| Qualcomm | N | * It is not clear why case 5 excludes RMSI and its scheduling PDCCH. * It is not clear if “configured SSB” refers to cell-defining SSB or not in case 5. * It is not clear whether semi-persistent PUCCH/PUSCH is categorized as “semi-statically configured UL transmission” or “dynamic scheduled UL transmission”. * In directional collision handling, it is good to clarify the content of PUCCH and the priority of PUSCH/PUCCH. |
| Nokia, NSB | Y |  |
| Xiaomi | Y |  |
| Intel | Y |  |
| OPPO | Y |  |
| DOCOMO | Y |  |
| China Telecom | Y |  |
| CATT | Y, almost | We invite companies to check whether ‘Valid PRACH occasion vs. DL reception’ from TDD shall be reused here, which is originally from current TS 38.213 Section 11:  For a set of symbols of a slot corresponding to a valid PRACH occasion and  symbols before the valid PRACH occasion, as described in Sublcause 8.1, the UE does not receive PDCCH, PDSCH, or CSI-RS in the slot if a reception would overlap with any symbol from the set of symbols. The UE does not expect the set of symbols of the slot to be indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*.  …  For a set of symbols of a slot corresponding to a valid PRACH occasion and symbols before the valid PRACH occasion, as described in Clause 8.1, the UE does not expect to detect a DCI format 2\_0 with an SFI-index field value indicating the set of symbols of the slotas downlink. |
| LG | N | In our view, they are not complete list to investigate. We share similar view with CATT in that collision with RO should be considered. To comply with the NR spec, the concept of valid RO should be maintained. So, we would like to add a bullet as suggested below.   * Dynamic or semi-static DL vs. RO   In general, as this is the first time we discuss collision issues, it would be hard to make a complete list anyway. Therefore, we would like the proposal to be formulated in a way that it is more accommodating future introduction of any collision issues that are identified in the following meetings. |
| NordicSemi | N | We think that 38.213 sub-clause 11 should be a starting point and we should discuss what should be done differently.  Agree that transmitted SSB and valid RO have special rules in R15/R16 in sub-clause 11, however, for HD-FDD they could be treated as regular semi-static RRC signal. |
| FL4 |  | **Medium Priority Proposal 6-2a:**   * For HD-FDD operation for RedCap UEs, consider at least the following DL/UL collision cases:   + 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. UL transmission     - e.g., PUSCH, PUCCH, PRACH, SRS   + Case 6: Monitoring for UL cancellation indication while transmitting in UL   + Case 7: Collision due to BWP switching   + Case 8: Dynamic or semi-static DL vs. RO |
| Qualcomm | Partially Y | UE is not expected to receive on DL or transmitted on UL during the gap (guard time) of switching from DL to UL. Therefore, we proposed to add the following case to Proposal 6-2a :  Case 9: Collision due to direction switching |
| Intel |  | We would like to clarify that the proposal does not imply that UE behavior would be defined for all of these cases. In our understanding, many of these can be avoided by proper gNodeB scheduling.  Also, it seems some of these cases can be compressed further at this stage. In this regard, we agree with NordicSemi that Case 8 can be handled under “dynamic or semi-static DL vs. semi-static UL” (Cases 1 and Case 3) without special listing. Similarly, Case 6 should be covered under “semi-static DL reception (PDCCH) vs. dynamic or semi-static UL tx” (Cases 2 and 3).   * For HD-FDD operation for RedCap UEs, consider at least the following DL/UL collision cases:   + 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, or RO   + 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. UL transmission     - e.g., PUSCH, PUCCH, PRACH, SRS   + ~~Case 6: Monitoring for UL cancellation indication while transmitting in UL~~   + Case 7: Collision due to BWP switching   + ~~Case 8: Dynamic or semi-static DL vs. RO~~ |
| DOCOMO | Y in principle | Cases 6/7 should be FFS as it has not been agreed whether or not RedCap UEs support UL CI or BWP switching |
| Huawei, HiSi |  | Not preferred as we have almost a principle (in FL3) to conditionally use the existing ones as starting point, then only additions need to be handled. But can live the it with similar conditions, i.e. if cannot be up to gNB handling without spec impact, and the Case 9 from Qualcomm can be included in Case7 with modification, thus   * + Case 7: Collision due to BWP switching/RF retuning |
| LG | Y | Okay with the FL4. Also agree with DOCOMO’s suggestion. |
| Vivo |  | We have following questions and comments   1. Is “UL transmission” in case 5 intended to cover both configured UL transmission and dynamic UL transmission, or just one of them, would be good to clarify. 2. Case 6 is already covered by case 3 and case 4, since monitoring for UL cancellation indication is not different from PDCCH monitoring. No need to separate it unnecessarily. 3. What is the relation between the above proposal and **High Priority Proposal 6.3c:** (copied below), we assume for all the cases listed here we will in principle reuse the existing Rel-15/16 handling as the starting point. Maybe it would be good to combine these two proposals for better clarify.   **High Priority Proposal 6.3c:**  For HD-FDD, the existing collision handling principles in Rel-15/16 NR are used as a starting point. |
| OPPO | Y |  |
| CATT | Y, mostly | Also agree with DOCOMO’s view. |
| TCL | Y |  |
| Apple |  | Ok to discuss. Agree with DoCoMo’s points about UL CI. |
| CMCC | Y | Also agree with Intel’s suggestion. |
| Sharp | Y | Same view with DOCOMO. |
| ZTE | Y, mostly | We show similar concern as Intel to clarify that the proposal does not imply that UE behavior would be defined for all of these cases.  For case 8, RO can be regarded as semi-statically configured UL transmission. Therefore, Dynamic vs. RO in Case 8 can be handled in Case 1 and semi-static DL vs. RO can be handled in Case 3.  For case 6/7, we agree with DOCOMO’s suggestion. |
| Panasonic | Y in principle | On case 6 and 7: As pointed out by Docomo, it is not stable whether the RedCap UE supports the UL CI or BWP switching. We propose to make them FFS or clarify like below: o Case 6: Monitoring for UL cancellation indication while transmitting in UL **if UL cancellation is supported by the RedCap UE** o Case 7: Collision due to BWP switching **if BWP switching is supported by the RedCap UE**  On case 5 and 8: We are open whether the special handling on SSB and RO is needed. If case 5 and 8 are kept in the proposal for the sake of progress, we recommend it is clarified that “Semi-statically configured DL” / “Semi-statically configured UL” in the cases 1-4 does not include SSB / RO (PRACH), respectively. |
| Samsung |  | We think it is better to focus on the general case. We don’t think Case 6/7 should be discussed as a separated case here.  For case 8, we are also fine with Intel’s change for case 8.  For Qc’s suggestion, we understand the motivation, however, it is not an additional case, but we should considering the switching time in general during defining the handling of cases. |
| Lenovo, Motorola Mobility | N | We don’t think all cases are necessarily valid. In general, due the flexible scheduling capability in gNB side, some collision might be avoided based on gNB implementation, i.e., the UE will not expect there will be collision happens for some cases, e.g., case 5. |
| Nokia, NSB | Y | We are fine to consider the proposed cases. |
| NordicSemi | Y, but | Fine to list cases, but we not sure this is the right approach. It would be better to discuss companies proposals about what they want to change compared to R15/R16. 😊 |
| InterDigital | Y |  |
| SONY | Y | In some ways, case 6 is covered by case 2/3/4. Our preference would be to keep case 6, but are also OK considering it under cases 2/3/4. We think that support of HD-FDD UEs should not negatively impact NR’s support for URLLC. |
| FUTUREWEI4 |  | The high priority proposals for this feature should be agreed before the medium priority proposals. |
| Ericsson | Y | As a start, we are okay to capture all the cases that need to be looked at. Then, we can discuss case-by-case, whether it is relevant to RedCap UEs, whether the existing rules can be adopted, or whether new rules are needed for RedCap UEs. |
| 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 |  | Considering the agreement on HD-FDD, companies are requested to provide input on the question below, where Case 5/6/7 has been modified and Case 9 has been added.  **Medium Priority Question 6-2b:**   * Is the list of DL/UL collision cases for HD-FDD operation for RedCap UEs below complete in your view? If not, what other collision cases should be considered for RedCap UE?   + Case 1: Dynamically scheduled DL reception vs. semi-statically configured UL transmission     - e.g., dynamic PDSCH or CSI-RS collides with configured SRS, PUCCH, CG PUSCH, or RO   + 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 6: Monitoring for UL cancellation indication (if supported) while transmitting in UL   + Case 7: Collision due to BWP switching (if supported)   + Case 8: Dynamic or semi-static DL vs. RO   + Case 9: Collision due to direction switching |
| Qualcomm | Y |  |
| CATT | Y | Fine with the current proposal.  For Case 8, we prefer to keep it. Maybe better to add ‘valid’ before ‘RO’. We understand that RO is one kind of RRC configured UL transmission. However, in current spec for TDD, confliction between valid RO and DL reception is specially treated. Unlike other RRC configured UL transmission, symbols of valid RO cannot be overwritten by any DL receptions, and UE does not expect symbols of valid RO to be conflict with DL direction, no matter indicated by common TDD configuration or UE dedicated TDD configurations or SFI indications. We think this implies that RO has higher priority than other RRC configured UL transmissions, and may need careful protection. |
| LG | Y |  |
| Xiaomi | Y |  |
| vivo | Almost Y | We are fine to list the different cases but have some questions. Could someone clarify why case 6 is special compared normal PDCCH monitroing as in case 2 or 3. Stricly speaking UL cancellation indication is not the only DCI that can cancel UL transmisiosn, SFI can also do that. So we are not sure what is the reason the list UL cancellation as a sepearte bullet |
| DOCOMO | Y |  |
| TCL | Y |  |
| China Telecom | Y |  |
| Intel | Y (almost) | Again, same question as before on Case 6 (as also asked by Vivo). Also, it seems now Case 8 can be deleted as it can be considered covered under Cases 1 and 3.  To CATT, even if “valid ROs" may be handled differently compared to other configured UL transmission occasions, such special handling can be part of the consideration of the general cases. We do not see the need to aiming for an exhaustive classification at this stage without clarity on which ones would eventually need spec handling. |
| Samsung |  | We also think Case 6 can be covered by Case 2(PDCCH collide with PUSCH/PUCCH) and case 3 (PDCCH vs CG PUSCH, etc), if Redcap UE supports UL CI.  Agree with vivo that we don’t need to treat Case 6 separately. |

# 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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| [2] | [R1-2100046](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100046.zip) | Complexity reduction features for RedCap UEs | FUTUREWEI |
| [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 |
| [4] | [R1-2100230](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100230.zip) | Potential solutions for UE complexity reduction | Huawei, HiSilicon |
| [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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| [9] | [R1-2100579](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100579.zip) | On complexity reduction features for NR RedCap UEs | MediaTek Inc. |
| [10] | [R1-2100625](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100625.zip) | Discussion on RedCap features | NEC |
| [11] | [R1-2100660](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100660.zip) | On UE complexity reduction for RedCap devices | Intel Corporation |
| [12] | [R1-2100772](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100772.zip) | UE complexity reduction features for RedCap | Lenovo, Motorola Mobility |
| [13] | [R1-2100823](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100823.zip) | Discussion on UE complexity reduction features | Spreadtrum Communications |
| [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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| [18] | [R1-2101049](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101049.zip) | Discussion on UE complexity reduction | CMCC |
| [19] | [R1-2101122](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101122.zip) | Discussion on the complexity reduction for Redcap | Xiaomi |
| [20] | [R1-2101214](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101214.zip) | UE complexity reduction | Samsung |
| [21] | [R1-2101390](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101390.zip) | On UE complexity reduction features for RedCap | Apple |
| [22] | [R1-2101766](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101766.zip) | Complexity Reduction for RedCap Devices (revision of [R1-2101471](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101471.zip)) | Qualcomm Incorporated |
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| [29] | [RP-202933](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_90e/Docs/RP-202933.zip) | New WID on support of reduced capability NR devices | Ericsson, Nokia |