3GPP TSG-RAN WG1 Meeting #109-e R1-22xxxxx

e-Meeting, 9th – 20th May 2022

**Agenda Item: 9.6.2**

**Title: FL summary #1 on simulation needs and assumptions for further reduce UE complexity**

**Source: Moderator (NTT DOCOMO, INC.)**

**Document for: Discussion, Decision**

# Introduction

This feature lead (FL) summary (FLS) concerns the Rel-18 study item (SI) on further NR RedCap (reduced capability) UE complexity reduction [1, 2, 3].

This document summarizes contributions [4] – [23] submitted to agenda item 9.6.2 and relevant parts of contribution [24] submitted to other agenda items and captures this email discussion on simulation needs and assumptions:

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| [109-e-R18-RedCap-03] Email discussion on simulation needs and assumptions by May 20 – Shinya (NTT DOCOMO)   * Check points: May 18 |

The issues that are in the focus of this round of the discussion are tagged FL1.

Follow the naming convention in this example:

* *eRedCapSimFLS1-v000.docx*
* *eRedCapSimFLS1-v001-CompanyA.docx*
* *eRedCapSimFLS1-v002-CompanyA-CompanyB.docx*
* *eRedCapSimFLS1-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 *eRedCapSimFLS1-v002-CompanyA-CompanyB.docx*.
* CompanyC uploads an empty file named *eRedCapSimFLS1-v003-CompanyB-CompanyC.checkout*
* CompanyC checks that no one else has created a checkout file simultaneously, and if there is a collision, CompanyC tries to coordinate with the company who made the other checkout (see, e.g., contact list below).
* CompanyC then has 30 minutes to upload *eRedCapSimFLS1-v003-CompanyB-CompanyC.docx*
* If no update is uploaded in 30 minutes, other companies can ignore the checkout file.
* Note that the file timestamps on the server are in UTC time.

In file names, please use the hyphen character (not the underline character) and include ‘v’ in front of the version number, as in the examples above and in line with the general recommendation (see slide 16 in [R1-2203012](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203012.zip)), otherwise the sorting of the files will be messed up (which can only be fixed by the RAN1 secretary).

To avoid excessive email load on the RAN1 email reflector, please note that there is NO need to send an info email to the reflector just to inform that you have uploaded a new version of this document. Companies are invited to enter the contact info in the table below.

**FL1 Question 1-1a: Please consider entering contact info below for the points of contact for this email discussion.**

|  |  |  |
| --- | --- | --- |
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This FLS should focus on aspects related to the following bullets in the work plan proposed in [2]:

* Discuss and agree what (LLS/SLS) simulations are needed.
* Discuss and agree on potential updates of the (link-budget/LLS/SLS) methodology/assumptions compared to TR 38.875.

# General aspects

As general aspects, following views are provided in the company contributions:

* RAN1 to discuss whether/which simulation results to plan to include in the Rel-18 TR [4]
  + it may not be worth the effort to “redo” the Rel-17 study for every technique
* Any planned simulations should include UE bandwidth reduction to 5MHz. [4]
* neither link-level simulation nor system-level simulation is essential to make a conclusion on the scope of Rel-18 RedCap WI [19]
* Do not duplicate the same evaluation that was already done in Rel-17 [23]
  + If needed, we can directly capture some results from TR 38.875 without redoing the same evaluation

Since the motivation for the necessary evaluations would be different from each other, **FL suggestion is to discuss which evaluations will be carried out individually in the ollowing sections.**

# 8 Coverage recovery

For coverage evaluation, following views on whether/which evaluations are necessary are provided in the company contributions:

* Evaluation is **NOT** necessary [6]
  + *UE bandwidth reduction and reduced UE peak data rate may have little impact on coverage*
  + *very limited TU for Rel-18 RedCap*
  + Data CH [8]
    - *along with the reduced bandwidth of (at least) baseband (e.g. 20 MHz → 5 MHz), the target data rate is also reduced (e.g. 50 Mbps → 10 Mbps) in a similar proportion*
  + SSB w/ 30KHz SCS [8]
    - *the SSB is 7.2 MHz, which cannot even be completely received by a UE with 5 MHz RF bandwidth*
* Evaluation is necessary
  + PBCH [5, 11, 12, 13, 14, 16, 20, 22]
    - when the SSB is configured with 30 kHz SCS
      * only 11 valid RBs can be received for eRedCap UE with 5MHz, while 20RBs are occupied by the PBCH
  + PDCCH [5, 8, 10, 12, 13, 14, 16, 20, 21, 22, 23]
    - If RF BW is reduced to 5MHz
      * CORESET with 24 PRBs in frequency domain and 3 symbols in time domain can support at most aggregation level (AL) 8 when the SCS of PDCCH is configured as 15 kHz
      * when SCS is configured as 30 kHz, the maximum AL of a candidate PDCCH is 4. No valid configuration for CORESET#0
  + PDCCH scheduling Msg2/4 [5]
  + PDSCH [5, 10, 12, 14, 21, 23]
    - limited frequency diversity gain for 5MHz bandwidth
    - w/ inter-BWP FH [21]
  + SIB1 [13, 14, 20]
    - If SCS is 30 kHz, SIB1 needs to be punctured
  + Msg2 [5, 12, 14]
  + Msg4 [5, 12, 14]
  + PUCCH [5, 12, 16, 21]
    - limited frequency diversity gain for 5MHz bandwidth
    - w/ RF retuning /inter-BWP FH [9, 21]
      * compare the performance for frequency hopping over 100MHz or 20MHz with 2-/4-symbol RF retuning gap vs. the performance for the frequency hopping over 5MHz without RF retuning gap
  + PUSCH [5, 10, 11, 12, 14, 16, 21, 23]
    - limited frequency diversity gain for 5MHz bandwidth
    - w/ RF retuning/inter-BWP FH [9, 21]
      * compare the performance for frequency hopping over 100MHz or 20MHz with 2-/4-symbol RF retuning gap vs. the performance for the frequency hopping over 5MHz without RF retuning gap
  + Msg3 [5, 12]
    - w/ RF retuning [9]
      * compare the performance for frequency hopping over 100MHz or 20MHz with 2-/4-symbol RF retuning gap vs. the performance for the frequency hopping over 5MHz without RF retuning gap
  + PRACH [5, 12]

As pointed out by some companies, which evaluations are necessary depends on the options for bandwidth reduction to be considered in this SI, i.e.,

* Option1: RF+BB bandwidth reduction to 5 MHz for all DL/UL channels [5, 9, 18, 21]
* Option2: BB bandwidth reduction to 5 MHz for all DL/UL data and control channels [9, 21]
* Option3: BB-only bandwidth reduction to 5 MHz for DL/UL data channels [5, 9, 18, 21]

Although moderator expects that the considered options would be discussed at first in AI 9.6.1, it is worth starting some discussion in parallel from 9.6.1. Given coverage evaluation have much interest from companies, moderator would propose at least Option1 of RF+BB BW reduction is considered in this study. The LLS results for Option1 can be reused for other options (e.g., PDSCH results for Options 2/3, PDCCH results for Option 2).

**FL1 High Priority Proposal 8-1:**

* **At least the option of RF+BB BW reduction to 5MHz for all DL/UL channels is considered for coverage evaluation**
  + **FFS whether/which other options are also considered**

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| **Company** | **Y/N** | **Comments** |
| Ericsson | Y | In addition to RF+BB BW reduction, we think that at least Option 3 (BB-only bandwidth reduction to 5 MHz for DL/UL data channels) should be considered for coverage evaluation.  For comparison, the impact of different BW reduction options on the coverage should be clear (even if there is no impact). A subset of Option 1 (RF+BB) evaluation results can be directly applicable to Options 2 and 3 and so additional work is expected to be quite small. |
| CATT |  | Even in (RF+BB) BW=5 MHz case, we think not all of the channels need evaluation. The channels who really need to be re-evaluated may be PDCCH and SSB (30 kHz) in this case. |
| Vivo | N | We do NOT think it is necessary to simulate all DL/UL channels for RF 5MHz for Coverage. It is sufficient to simulate some channels like PBCH, CORESET#0 for 5MHz RF BW. At least the DL/UL data chanenls and PUCCH does not need to be simulated from coverage perspective given the repetition and mehanisms developed in Rel-17 Cov\_enh. Can be used. |
| ZTE, Sanechips |  | From our understanding, the coverage evaluation for option2 and option3 can refer to the results for option1.  However, whether all the DL/UL channels requires the simulation need further discussion. From our point of view, PDCCH and PBCH for option1 are needed and the others DL/UL channel may need some discussion. |
| CMCC |  | Exhaustive coverage evaluation is not needed. The affected channels are PBCH, PDCCH, SIB1 PDSCH. Then maybe we can examine the R17 results and find the gap between them and the bottleneck channel, and then check whether the performance loss due to bandwidth reduction to 5MHz is within the gap.  If not, then we can discussion solutions, such as separate CORESET#0, reduced payload size, limited SCS, etc. |
| Samsung |  | Even if Option 1 is considered, we think specific channels (e.g., DL channels) instead of all DL/UL channels can be evaluated taking into account limited TU for SI and limited performance impacts on some channels from BW reduction (e.g., UL channels). |
| DOCOMO | Y | For the FFS, in addition to RF+BB BW reduction, it would be good to evaluate BB-only BW reduction since it would be worth to evaluate the compareion of frequency diversity gain between RF+BB BW reduction and BB-only BW reduction. |
| IDCC | Y |  |
| Nordic | N | We do not think UL channels are of concern since R17 Cov\_enh can be used to compensate.  We should focus on DL signals SSB, PBCH, PDCCH in IDLE mode.  In RRC connected full-scale MIMO can be used to provide coverage, no bottleneck is seen there either. |
| Intel | Y | Assuming Option1 for RF+BB BW reduction is simulated, we basically get all evaluation results for all 3 options. For example, for data channel, the evaluation results can be from the evaluation for RF+BB BW reduction, while for control channel, it is same as Rel-17 RedCap UE.  Therefore, observations on all options can both be obtained. |
| Nokia, NSB | Y | Options to evaluate depends on the outcome of the discussion in 9.6.1.  However, we think coverage evaluation for RF+BB reduction to 5 MHz is an important case and therefore should be considered. |
| LGE | Y | Link level simulation results for option 1 can be used to identify and verify potential performance impact. Especially, evaluations for PDCCH with limited AL and SSB with 30kHz SCS are very helpful. |
| FUTUREWEI |  | Note that R18 is much smaller than R17 in scope, and objectives like coverage recovery and power savings were not included in the SID. So while RAN1 can still decide by consensus to perform some evaluations for coverage. We also feel that even if we look at link budgets, studying coverage recovery techniques is beyond the scope or TU of the SI other than maybe listing some possibilities in the Performance subsections. So for now we recommend to the FL not to call the section of the paper “Coverage recovery” but just “Coverage”. |
| Qualcomm | Partly Y | We generally agree on the proposal. However, we need to discuss which channels to be evaluated. Our preference is to study the link budget at least for PBCH/PDSCH/PDCCH/PUSCH. |
| Huawei, Hisilicon |  | Coverage recovery is out of SI scope. Detailed coverage recovery evaluation is not necessary considering the very limited TU. Evaluation for coverage can be considered, but not for excessive coverage recovery. Therefore, we suggest not to call this section “Coverage recovery”.  Additionally, we don’t feel UL coverage evaluation is necessary because uplink is Tx power limited rather than bandwidth limited. For a Rel-18 RedCap UE targeting lower peak date rate, BW reduction to 5MHz does not causes UL coverage reduction,  For DL, only SS/PBCH and PDCCH evaluations is sufficient. Given the limited TU, we feel the other DL evaluations in Rel-17, like RAR evaluation is unnecessary. |
| Lenovo |  | We think only need to evaluation coverage for some DL channels like PBCH, PDCCH and SIB1 PDSCH.  Actually, our understanding is that before conducting any performance evaluation for coverage, we need to decide which BW reduction candiate to be agreed/excluded. The decision could mostly based on the evaluation of complexity reduction and the analysis on the standard impact, etc, even not based on coverage performance. |
| Xiaomi | Y | The option of RF+BB BW reduction to 5MHz for all DL/UL channels can bring the most cost gain, thus it is the most significant case to evaluate.  Besides,since this option covers all channels, only evaluating the coverage of this option is sufficient and the results can be reused for other options, such as only BB bandwidth for data channels reduction to 5MHZ. |

8.0 Evaluation methodology for coverage recovery

For the evaluation methodology for coverage recovery, following views are provided in the company contributions:

* The methodology in TR 38.875 is reused for the determining the target performance for coverage recovery in the Rel-18 eRedCap SI [5, 12, 14]

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| - Step 1: Obtain the link budget performance of the channel based on link budget evaluation  - Step 2: Obtain the target performance requirement for RedCap UEs within a deployment scenario  - Step 3: Find the coverage recovery value for the channel if the link budget performance is worse than the target performance requirement  The target performance requirement for each channel is identified by the link budget of the bottleneck channel(s) for the reference NR UE within the same deployment scenario. The "bottleneck channel(s)" are the physical channel(s) that have the lowest MIL |

* UE antenna efficiency loss of 3 dB
  + Discuss whether the UE antenna efficiency loss of 3 dB that was assumed for Rel-17 RedCap UEs in FR1 in TR 38.875 should be included in link budget evaluations in the Rel-18 eRedCap SI [5]
  + Reused [12, 14]
* Reuse Table 6.3-1 in 38.875 [5, 12, 14, 21, 23]
* Considered UE type
  + Reference UE
    - Reuse Table 6.3-2 in 38.875 [5, 12]
  + Rel-17 RedCap
    - simplest RedCap UE that was specified in Rel-17 for FR1 [5]

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| **Parameters** | **FR1 values** |
| # UE Tx chains | 1 |
| # UE Rx chains | 1 |
| UE bandwidth | Rural: 20 MHz (106 PRBs, 15 kHz SCS)  Urban: 20 MHz (51 PRBs, 30 kHz SCS) |

* + 5MHz-BW RedCap
    - 1 Rx [5, 14]
    - 1 Rx or 2Rx [12, 13, 23]

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| **Parameters** | **FR1 values** |
| UE bandwidth | Rural: 5 MHz (25 PRBs, 15 kHz SCS)  Urban: 5 MHz (11 PRBs, 30 kHz SCS) |

* CH specific simulation parameters
  + PBCH [5, 13, 14]
    - To be discussed whether any update from Table A.1-8 in TR 38.830 is necessary for 5MHz-BW RedCap
    - for a RedCap UE with a bandwidth of 5 MHz and with 30 kHz SCS, the UE is assumed to be able to receive only 144 subcarriers [14]
  + PRACH [5]
    - To be discussed whether any update from Table A.1-4 in TR 38.830 is necessary for 5MHz-BW RedCap
    - The size of the PRACH occasion in the frequency domain expressed in number of RBs for PUSCH (c.f. TS 38.211, Table 6.3.3.2-1) is determined based on the preamble sequence length, LRA, SCS for PRACH, and SCS for PUSCH. For PRACH format B4 with 30 kHz SCS and 30 kHz SCS PUSCH, the number of RBs occupied will be 12 RBs (with starting subcarrier of the preamble sequence = 2). However, for a UE with 5 MHz BW and 30 kHz SCS, the maximum transmission BW is only 11 RBs. The number of preamble subcarriers that fits within the 11 RBs is 127 (assuming is the same). Therefore, for the 5 MHz-UE, we consider LRA = 127. [5]
  + PDCCH [5, 13, 14, 21]
    - To be discussed whether any update from Table A.1-7 in TR 38.830 is necessary for 5MHz-BW RedCap
    - for a RedCap UE with a maximum channel bandwidth of 5 MHz, the aggregation level is 8 using a CORESET size of 24 PRBs and 2 OFDM symbols with 15 kHz SCS, and the aggregation level is 1 using a CORESET size of 6 PRBs and 1 OFDM symbol with 30 kHz SCS [14]
    - Note that with the 5 MHz UE maximum RF bandwidth, the largest CORESET that fits within the UE bandwidth has size of 24 PRBs (15 kHz SCS) and 3 symbols. In this case, the maximum possible PDCCH aggregation level (AL) confined within the UE bandwidth is 8. However, for some other CORESET configurations, the CORESET bandwidth can exceed the maximum UE bandwidth, such as: (48 PRBs, 15 kHz SCS), (96 PRBs, 15), (24 PRBs, 30 kHz SCS), and (48 PRBs, 30 kHz SCS). Therefore, for such configurations (which can be shared with legacy UEs), if the UE is constrained to have 5 MHz RF bandwidth, it must skip/puncture the PRBs that fall outside of its Rx bandwidth.
  + PDSCH [5]
    - To be discussed whether any update from the target data rate in TR 38.875 is necessary for 5MHz-BW RedCap
      * The target data rate for 5-MHz RedCap UE in DL and UL is the scaled value of the Rel-17 RedCap UE by a factor of 0.25 if UE antenna efficiency loss (3 dB) is assumed and by a factor of 0.5 if there is no assumption of the antenna efficiency loss.[5]
      * the target data rate for PDSCH is scaled down relative to Rel-17 RedCap UE in proportion to the bandwidth reduction [14]
        + 1Mbps to 250kbps, 10Mbps to 500kbps
      * A linear scaling factor 1/4 can be applied to derive the DL target data rate for F-RedCap UE, i.e. 0.5Mbps for Urban and 0.25Mbps for Rural [21]
    - To be discussed whether any update from Table A.1-6 in TR 38.830 is necessary for 5MHz-BW RedCap
  + SIB1 [13, 14, 21]
    - To be discussed whether any update from Table A.1-6 in TR 38.830 is necessary for 5MHz-BW RedCap
    - a TBS of 1256 bits [14]
  + Msg2 [5, 14]
    - To be discussed whether any update from Table A.1-6 in TR 38.830 is necessary for 5MHz-BW RedCap
    - To be discussed whether any update from Table 6.3-4 in TR 38.875 is necessary for 5MHz-BW RedCap
    - payload of 72 bits [5, 14]
  + Msg4 [5, 14]
    - To be discussed whether any update from Table A.1-6 in TR 38.830 is necessary for 5MHz-BW RedCap
  + PUCCH [5, 21]
    - To be discussed whether any update from Table A.1-3 in TR 38.830 is necessary for 5MHz-BW RedCap
  + PUSCH [5, 21]
    - To be discussed whether any update from the target data rate in TR 38.875 is necessary for 5MHz-BW RedCap
      * The target data rate for 5-MHz RedCap UE in DL and UL is the scaled value of the Rel-17 RedCap UE by a factor of 0.25 if UE antenna efficiency loss (3 dB) is assumed and by a factor of 0.5 if there is no assumption of the antenna efficiency loss.[5]
      * the target data rate should be reduced for a 5 MHz UE [14]
      * The scaling on the UL target data rate is not necessary. However, it would be reasonable that the UL target data rate is not more than the corresponding DL target data rate. Based on such criteria, UL target data rate for F-RedCap UE can be 0.5Mbps for Urban and 100Kbps for Rural. [21]
    - To be discussed whether any update from Table A.1-2 in TR 38.830 is necessary for 5MHz-BW RedCap
  + Msg3 [5]
    - To be discussed whether any update from Table A.1-5 in TR 38.830 is necessary for 5MHz-BW RedCap

As mentioned in **Proposal 8-1**, at least Option1 of RF+BB BW reduction should be considered in this study. To avoid lengthy discussion of evaluation assumption for each channel, moderator would ask following two questions:

**FL1 High Priority Question 8.0-1:**

* **Companies are encouraged to provide view on whether/which LLS results can be reused for reference UE and Rel-17 RedCap UE from TR 38.875.**

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| **Company** | **Comments** |
| Ericsson | It only needs to be agreed that LLS *assumptions* for the reference UE and the Rel-17 RedCap UE from TR 38.875 can be reused. Whether LLS *results* need to be reused or be updated can be up to individual companies. |
| CATT | We think LLS results can be reused for reference UE and Rel-17 RedCap UE. The TR 38.875 already includes the simulation assumptions for legacy UE and the represented simplest Rel-17 RedCap (i.e. 1Tx and 1Rx, while HD-FDD and modulation order does not have impact on LLS). We can focus on the LLS for Rel-18 eRedCap UE with further reduced bandwidth. |
| vivo | For reference UE and Rel-17 RedCap UE, we think the LLS results in TR38.875 all can be reused. |
| ZTE, Sanechips | Some simulation assumptions from TR38.875 can be reused in principle for Rel-18 coverage evaluation. The simulation results need to be updated based on specific features，e.g, PDDCH aggregation level reduction, uncompleted PBCH reception. |
| CMCC | Can be reused. |
| Samsung | In general, we think all LLS results from TR38.875 can bacially be reused for reference UE and Rel-17 RedCap UE. But, there is no need to agree it because it is up to each company. |
| DOCOMO | We think all the LLS results for reference UE and Rel-17 RedCap UE in TR38.875 can be reused. |
| IDCC | Same view as ZTE. |
| Nordic | It depends whether R17 simulations are reused or not. And at least we have a concern on number of Tx chains at gNB in R17 assumptions for LLS. |
| Intel | we support to reuse evaluation assumptions from 38.875 |
| OPPO | Reuse the evaluation assumption. |
| Intel | we support to reuse evaluation assumptions from 38.875 |
| Nokia, NSB | LLS results for reference NR UE and Rel-17 RedCap UE can be reused as appropriate. |
| LGE | We prefer to reuse LLS results from TR 38.875 as much as possible to minimize simulation efforts. |
| FUTUREWEI | It is a bit hard to answer this question or the next without discussing some of the changes to e.g. the target data rate for a link budget. For that, our view is that we should scale with BW in a similar way as we did in Rel-17. Agree with Ericsson that it could be up to the company whether to reuse or update results. |
| Qualcomm | Reuse the evaluation assumption from 38.875. |
| Huawei, Hisilicon | In our view, all the LLS results for reference UE and Rel-17 RedCap UE from TR 38.875 can be reused. |
| Xiaomi | Reuse simulation results for reference NR UE and Rel-17 RedCap UE in TR38.875. |

**FL1 High Priority Question 8.0-2:**

* **Companies are encouraged to provide view on what additional LLS results are necessary in the Rel-18 RedCap SI for reference UE, Rel-17 RedCap UE, and Rel-18 RedCap UE with 5MHz BW.**

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| **Company** | **Comments** |
| Ericsson | At least for Rel-18 bandwidth reduction Option 1 (RF+BB), link budget analysis covering all physical channels should be carried out. Therefore, LLS results for all the channels for the 5-MHz UE are needed. Most of the LLS assumptions for the Rel-17 RedCap UE could be reused for the 5-MHz UE. However, some parameters may need to be updated for the 5-MHz UE (e.g., occupied BW, cell-edge target data rate, etc.).  Regarding additional LLS results, as also pointed out by several companies, we think SIB1 should be part of link budget analysis. Since SIB1 was not considered in Rel-17, LLS for SIB1 would be needed for the reference UE, the Rel-17 RedCap UE, and the 5-MHz UE. |
| CATT | Regarding the question on ‘necessary additional LLS results’, we do not see there is strong need. For SIB1, maybe considerable, but one critical issue is its typical payload size, which highly depends on network deployment. It is unclear whether we really have to use up to 3000 bits? |
| vivo | For 5MHz RF BW, to support 30KHz SCS, performance loss is expected. Due to limited SI time, we think it is more efficient to assess the performance for some channels taking RF retuning into account. For example,   * For SSB/CORESET#0, simulate the reception of the channel within 5MHz without RF retuning, and with RF retuning and combining the receptions. * For PUCCH/PUSCH,  1. Investigate the frequency diversity loss of 5MHz compared to 20MHz 2. Investigate whether RF retuning with reasonable retuning gap can make up for this loss |
| ZTE, Sanechips | For RF+BB bandwidth reduction, the available aggregation level for PDCCH is limited. The coverage performance evaluation is needed for PDCCH. For PBCH with 30KHz SCS, it also can not be received by the 5M bandwidth UE completely. Therefore, PBCH and PDCCH should be evaluated with high priority. |
| CMCC | For R18 RedCap with 5MHz, the affected channels such PBCH, PDCCH, SIB1 PDSCH can be evaluated. For SIB1, the performance rely on payload size as CATT mentions.  And vivo’s suggestion for RF retuning and combining different part of period signals can also be considered. |
| Samsung | We don't think additional LLS results are necessary for reference UE and Rel-17 RedCap UE. Only things to be considered are about whether or how to evaluate Rel-18 RedCap UE with 5MHz. |
| DOCOMO | For RF and BB BW reduction to 5MHz, we think the link budget analysis should be evaluated at least for UL channels to evaluate whether/how the frequency diversity gain would be lost even if frequency hopping is applied.  In addition, we share the similar view with vivo that RF retuning should be considered as a potential solution and evaluated in the SI phase. More specifically, the following evaluations can be considered;   * SSB reception w/ RF retuning which is configured with 30 kHz * PDCCH reception w/ RF retuning with MIB-configured CORESET#0 which is configured with 48/96 RBs for 15 kHz SCS and/or 24/48/96 RBs for 30 kHz SCS   In addition, to compensate the expected coverage loss due to the restricted AL for PDCCH with 5MHz BW, PDCCH repetition can be a candidate solution and we propose to consider this as a target LLS scenario. |
| IDCC | PBCH, PDCCH and SIB1 need to be considered due to 5 MHz BW. |
| Intel | We don’t see a necessity to evaluate the reception of particially punctured PDCCH in CORESET#0 and SIB1 PDSCH. In fact, it requires further discussion on the total BW without puncturing, details of puncturing scheme, etc.  For PDCCH, since 3 OFDM symbols with 5MHz BW can only provide 12 CCEs, CORESET bundling can be simulated for at least PDCCH AL=16.  For data channel, it is common understanding there is loss on frequency diversity. Then, inter-BWP hopping may be evaluated, however, BWP switching time is a limitation factor for the gain which should be considered too. |
| OPPO | We can consider for 5MHz without puncturing, LLS results or Linkbudget analysis to be performaned to study the coverage issue of narrow band.  If some additional operation, e.g. 5MHz for 30kHz SCS, is justified for supporting. We can also consider the LLS evaluation of 5MHz RF for supporting the case. Also the mechanism for operation should be clarified first. |
| Nokia, NSB | Additional LLS results are necessary for Rel-18 RedCap UE with 5 MHz RF+BB BW as follows.  PBCH (Urban/30 kHz SCS): Limit the receive BW to 144 subcarriers.  PRACH (Urban/30 kHz SCS): Limit the number of preamble subcarriers to 127 for PRACH format B4 (assuming ).  PDCCH (Rural/15 kHz SCS, Urban/30 kHz SCS): Limit CORESET size to 24 PRBs/3 symbols (max AL = 8) for Rural and 6 PRBs/2 symbols (max AL = 2) for Urban.  PDSCH (Rural/15 kHz SCS, Urban/30 kHz SCS: LLS with FDRA in 5 MHz based on scaled down data rate (TBD).  SIB1(Rural/15 kHz SCS, Urban/30 kHz SCS): Selected payload (TBD) and FDRA (TBD).  Msg2 (Urban/30 kHz SCS): Payload of 72 bits and FDRA limited to 11 PRBs.  Msg4: Payload of 1040 bits and same FDRA assumption as SIB1.  PUSCH (Urban/30 kHz SCS: LLS with FDRA in 5 MHz based on scaled down data rate (TBD). |
| LGE | We think that the channels that would inevitably have coverage loss for BW reduced Rel-18 RedCap UE have to be evaluated. Companies may have different views on the channels for coverage evaluation as it somehow depends on the bandwidth reduction options. If it is the case, then we can further discuss which channels to evaluate or we can just leave it to companies to make a choice. |
| FUTUREWEI | Additional LLS may be needed if *there is substantially* new UE behavior for Rel-18 RedCap UEs and/or modification of channels is being considered |
| Qualcomm | For 5MHz BW option, at least PDCCH (15/30KHz SCS) and PBCH (30KHz SCS) need to be evaluated with potential coverage recovery options. |
| Huawei, Hisilicon | For 5MHz BW, in the evaluation for periodic DL signals like SIB1 and SS/PBCH, UE reception combination with RF retuning can be considered if the DL signal setting has larger bandwidth than 5MHz. |
| Xiaomi | PDCCH (15/30KHZ SCS) with puncturing and/or with lower AL, PBCH (30KHZ SCS) and SIB1 need to be evaluated for coverage.  Besides, frequency diversity gain and frequency selective gain for data channels, i.e., PDSCH and PUSCH should be evaluated due to the narrower bandwidth. |

8.1 Introduction to coverage recovery

[Placeholder]

8.2 Coverage recovery evaluation

[Placeholder]

8.3 Coverage recovery for <CHANNEL>

For the coverage recovery techniques, following views are provided in the company contributions, **which will be discussed once necessary evaluations are decided**:

* PBCH
  + Longer acquisition time allows multiple trials of SSB/SI acquisition [5]
  + PBCH reception across multiple times [16]
  + RF retuning after detecting the PSS and SSS successfully with increased cell search delay [11]
  + design a new channel to replace the legacy PBCH [22]
  + use only 15 kHz SCS for SSB [22]
* SI acquisition
  + Longer acquisition time allows multiple trials of SSB/SI acquisition [5]
* PDCCH
  + Reduce DCI sizes [5]
  + Introducing a higher aggregation level [5]
  + frequency hopping CORESET [5]
  + PDCCH repetition [5, 16, 21]
  + PDCCH reception across multiple times [16]
* PDSCH
  + frequency hopping [5, 21]
  + PDSCH repetition [5]
* PRACH
  + Repeat random access attempts [5]
  + Use longer PRACH preambles [5]
* PUCCH
  + Use a longer PUCCH format [5]
  + PUCCH repetition [5]
  + frequency hopping [21]
* PUSCH
  + Use slot aggregation [5]
  + frequency hopping [5, 21]
  + BWP larger than maximum UE bandwidth [11]
  + Optimize the BWP framework [11]

9 Impact to network capacity and spectral efficiency

For network capacity and spectral efficiency, following views on whether the SLS evaluation are necessary are provided in the company contributions:

* SLS for network capacity and spectral efficiency is **NOT** necessary [5, 6, 8, 23]
  + Both UE bandwidth reduction and reduced UE peak data rate have little impact on network capacity and spectral efficiency
  + The network capacity and spectral efficiency are usually affected by the reduced peak data rate caused by the relaxation of maximum number of MIMO layers and maximum modulation order
  + improving the system capacity is not included in the SI scope
  + very limited TU for Rel-18 RedCap
* Spectral efficiency and UE throughput in co-existence of eMBB, Rel-17 RedCap UEs and Rel-18 RedCap UEs should be evaluated [10(?), 12, 14]
  + excessive SSB resource usage and less frequency diversity gain may result in some performance degradation on network capacity and spectral efficiency
  + reuse evaluation methodology for system level simulations in TR38.875 [12, 14]
  + Keep urban macro at 2.6 GHz in TDD as the main deployment configurations for SLS evaluation [14]
  + To be discussed whether any update from Section 6.4 in TR 38.875 is necessary

**FL1 High Priority Question 9-1: Companies are encouraged to provide views on whether the SLS evaluation are necessary for network capacity and spectral efficiency.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson |  | We do not see a strong need for SLS for studying network capacity and spectral efficiency impacts in Rel-18, considering that the main motivation for SLS in the Rel-17 RedCap SI was to study the impact of reduction of number of Rx branches and that we have limited TUs available to conclude the Rel-18 eRedCap SI.  Also, in TR. 38.875, the following statement was captured on the impact of UE BW reduction on network capacity and spectral efficiency for Rel-17 RedCap:  *Bandwidth reduction in FR1 will not have a significant impact on capacity and spectral efficiency, although there may be some minor degradation due to the loss in frequency selective scheduling gain.*  However, if proponents could provide a good enough motivation, we would be open to consider SLS in the SI. We would also be fine with capturing qualitative assessments of network capacity and spectral efficiency impacts due to the complexity reduction techniques in TR 38.865 (as we did in TR 38.875). |
| CATT | N | The network capacity and spectral efficiency are mainly affected by the relaxation of maximum number of MIMO layers and maximum modulation order. They are unlikely to be largely affected due to the reduction of bandwidth alone. In addition, improving the system capacity is not included in the SI scope.  In fact, we do not need to worry too much about network capacity. Network can control the access/barring of RedCap UE to balance the capacity. |
| vivo | N | As observed in TR. 38.875, the bandwidth reduction will not have a significant impact on capacity and spectral efficiency, and the SI time is quite limited, no strong jusitification is found to do the SLS. |
| ZTE, Sanechips | N | In Rel-17, reduced number of Rx antennas and layers and relaxed modulation order would cause network capacity and spectral efficiency degradation，therefore SLS is needed.  However, in Rel-18, at least for UE BW reduction, no significant network capacity and spectral efficiency impacts are foreseen. Considering the limited TU and massive efforts for parameter alignment, SLS is not necessary. |
| CMCC | N | Separate section for this may not be necessary. Company can bring up evaluation along with performance impact of each solution in section 7.2.3 or 7.3.3. |
| Samsung | N | We don't see a strong need of SLS in Rel-18. Impact on network capacity or spectral efficiency from BW reduction, relaxed UE processing time and also the reduced peak data rate (caused by the relaxed maximum number of MIMO layers and maximum modulation order) was already analyzed in Rel-17 RedCap and then captured in TR38.875. |
| DOCOMO | N | As commented by companies, it is captured in TR38.875 that BW reduction will not have a significant impact on the network capacity and spectral efficiency, and hence we don’t see the need for SLS to evaluate at this point. |
| IDCC | N |  |
| Nordic | N |  |
| Intel | N | The main feature for complexity reduction is BW reduction or relaxed processing time, both features are not expected to have large impact to network capability and spectral efficiency. |
| OPPO | N | No SLS is needed at this moment. |
| Nokia, NSB |  | We think it would be beneficial to perform SLS evaluations to evaluate the network capacity and spectral efficiency as we do see some impact. We do agree that the expected impact from BW reduction should be small. Therefore, if the majority view is not to have SLS evaluations then we are fine to accept majority view. |
| LGE | N | We don’t think SLS evaluation is necessary for network capacity and spectrail efficiency. Given the scope of Rel-18 RedCap SI, SLS is not essential to make a conclusion on the scope of Rel-18 RedCap WI. Also, we have very limited time for evaluations and discussions, so we believe that it is better to focus on essential issues. |
| FUTUREWEI |  | We think that no network capacity simulations are needed. The simulations are both out of scope of the SI and also not needed, as the network impact concern is mainly of a deployment nature and not on whether low data rate UEs are worth supporting in the network from a capacity perspective. |
| Qualcomm | N | No SLS evaluation is needed for Rel-18 study item |
| Huawei, Hisilicon | N | All the studied UE cost reduction techniques, such as UE bandwidth reduction, UE peak data rate reduction, relaxed UE processing time have little impact on network capacity and efficiency. SLS simulation is not necessary. |
| Xiaomi | N | SLS on netwok capacity and spectral efficiency is not needed, since all the cost reduction solution has limited impact on them. SLS on eRedCap UE average throughput may need to evaluate for relaxed processing timline and HARQ process number reduction if studied. |

# 10 Other evaluations

For other evaluations, following views on whether/which evaluations are necessary are provided in the company contributions:

* O1: PDCCH blocking probability
  + depends on which bandwidth reduction option will be agreed [8, 11]
    - When RF bandwidth is reduced to 5MHz, a narrower CORESET with fewer PDCCH candidates may increase the blocking probability even if lower aggregation level is used
    - if the CORESET is allowed to be shared by Rel-18 RedCap UEs and legacy UEs including Rel-17 RedCap UE, PDCCH blocking will be more serious
  + Reuse the PDCCH AL distributions as in Rel-17 RedCap TR 38.875 [23]
    - Any modification of AL distributions to be reported by companies (e.g., restriction on some ALs by BW reduction)
  + To be discussed whether any update from Table 6.2-4 in TR 38.875 is necessary
* O2: Latency
  + Whether to evaluate the latency for relaxed N1/N2 should be determined with high priority [10]
  + For reduced number of HARQ processes [11]
    - singficant impact on the overall delay of the payload and indirectly impact on the system throughput
* O3: Throughput
  + For TBS restriction [11]
    - singficant impact on the overall delay of the payload and indirectly impact on the system throughput
* O4: Power saving gain
  + discuss if it needs to evaluate and compare power saving gain of the candidate solutions for complexity reduction, given that different solution may provide different power gain [17]
* [7, 10, 12, 15, 17, 18, 23] discuss cost evaluation aspects, which will be discussed in AI 9.6.1.

**FL1 High Priority Question 10-1: Companies are encouraged to provide views on which evaluations listed above are necessary.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Supported evaluations (O1/O2/O3/O4)** | **Comments** |
| Ericsson | O1 and O2 | O3: We do not think evaluations to study the impacts of TBS restriction should be prioritized. However, we would be fine with capturing qualitative assessments of the impacts, e.g., in Clause 7.3.3 of TR 38.865 (if endorsed).  O4: Unlike Rel-17 RedCap SI, UE power saving is not part of the objectives of Rel-18 eRedCap SI. |
| CATT | O1 | We think O1 can be considered, if the bandwidth of PDCCH is redued to 5 MHz.  Other evaluations are not critical. |
| vivo |  | We do not think O1 ~ O4 is needed.  For O1, for the connected R18 eRedCap UE, gNB can configure the CORESET properly. For idle/inactive R18 eRedCap, it can also be controlled by gNB, depending on whether there is PDCCH blocking issue, gNB can decide whether the shared or separate CORESETs for R18 eRedCap and non-RedCap UE should be used.  For O2, double the processing timeline, as evalueated in our contribution R1-2203572, the latency requirement can still be satisfied.  For O3, we do not think it will bring significate loss to the overall system throughput.  For O4, it can be low priority for this study, quantitative analysis is not needed. |
| ZTE, Sanechips | O1 and O2 |  |
| Samsung |  | We think which evaluations are further needed depends on proposals by proponents and so, there is no need to agree on further evaluations. |
| DOCOMO | O1 | For O1, it can be expected that the PDCCH blocking rate may be increased with 5MHz RF BW.  For O4, we are open but don’t see the strong need for evaluation campaign and it can be evaluated with low priority. |
| IDCC | O1, O2 |  |
| Nordic |  | No need to study any of these. |
| Intel | O1 | If duration of CORSET is not increased and CORSET bundling is not supported, it will be necessary to evaluate PDCCH blocking rate since there are only quite limited CCEs in the CORESTE. On the other hand, if CORESET bundling or larger duration of CORESET is supported, we don’t see a necessity for the evaluation of PDCCH blocking rate |
| OPPO | O1 | We can consider the blocking issue due to the much lower availiby CORESET resource. |
| Nokia, NSB | O1 | For BB+RF reduction to 5MHz, PDCCH blocking can be studied. |

|  |  |  |
| --- | --- | --- |
| LGE | O1 | For O1, if option1: RF+BB BW reduction is considered, PDCCH blocking rate is expected to be increased due to restriced CORESET with fewer PDCCH candidates. We think it is worth evaluating PDCCH blocking rate. |
| FUTUREWEI |  | O4 is out of scope, O3 may not be needed. Open to at least statements on blocking and latency, not sure yet if evaluations are necessary, though if companies provide results, we can discuss. |
| Qualcomm | O1 | For 5MHz BW CORESET option, we need to perform evaluation for PDCCH blocking probability. For 20MHz BW CORESET option, we already have sufficient results in TR38.875 so we can reuse them. |
| Huawei, HiSilicon |  | O4 is out of scope.  O2 is not necessary at least for doubling N1/N2. |
| Xiaomi | O1 and O2 |  |

# References

|  |  |  |  |
| --- | --- | --- | --- |
| [1] | RP-213661 | New SID on Study on further NR RedCap UE complexity reduction | Ericsson |
| [2] | R1-2204058 | Work plan for Study on further NR RedCap UE complexity reduction | Rapporteur (Ericsson) |
| [3] | R1-2203121 | Draft skeleton for TR 38.865 Study on further NR RedCap UE complexity reduction | Rapporteur (Ericsson) |
| [4] | R1-2203055 | Simulations for the Rel-18 RedCap SI | FUTUREWEI |
| [5] | R1-2203118 | Simulation needs and assumptions for further RedCap UE complexity reduction | Ericsson |
| [6] | R1-2203170 | Discussion on simulation needs and assuptions | Huawei, HiSilicon |
| [7] | R1-2203339 | Discussion on evaluation needs and assumptions for eRedCap | Spreadtrum Communications |
| [8] | R1-2203474 | Views on evaluation needs based on different assumptions | CATT |
| [9] | R1-2203573 | Discussion on potential simultion for eRedCap | vivo, Guangdong Genius |
| [10] | R1-2203601 | Evaluation requirements for Rel-18 RedCap UE | ZTE, Sanechips |
| [11] | R1-2203828 | Simulation needs and assumptions on further NR Redcap UE complexity reduction | xiaomi |
| [12] | R1-2203918 | Evaluations for eRedCap | Samsung |
| [13] | R1-2203996 | Simulation and evaluation for RedCap enhancement | OPPO |
| [14] | R1-2204039 | Evaluation assumptions for further complexity reduction | Nokia, Nokia Shanghai Bell |
| [15] | R1-2204316 | Discussion on simulation needs and assumptions | CMCC |
| [16] | R1-2204390 | Discussion on simulations and assumptions for further UE complexity reduction | NTT DOCOMO, INC. |
| [17] | R1-2204505 | Evaluation needs and assumptions for further NR RedCap | Lenovo |
| [18] | R1-2204583 | Discusion on simulation needs and assumptions | Transsion Holdings |
| [19] | R1-2204627 | Discussion on simulation needs for further UE complexity reduction | LG Electronics |
| [20] | R1-2204715 | On simulation needs and assumptions for RedCap UEs | MediaTek Inc. |
| [21] | R1-2204810 | On simulations for further reduced UE complexity | Intel Corporation |
| [22] | R1-2204830 | Simulation needs for further RedCap UE complexity reduction | InterDigital, Inc. |
| [23] | R1-2205044 | Evaluation for eRedCap SI | Qualcomm Incorporated |
| [24] | R1-2203119 | Initial evaluation results for further RedCap UE complexity reduction | Ericsson |