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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| --- | --- | --- |
| **Company** | **Point of contact** | **Email address** |
| Ericsson | Sandeep Narayanan Kadan Veedu | sandeep.narayanan.kadan.veedu@ericsson.com |
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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.

# 2 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 folloiwng 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. |
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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. |
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**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. |
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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.**

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| **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). |
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# 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.**

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| **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. |
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# References

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| --- | --- | --- | --- |
| [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 |