**3GPP TSG RAN meeting #96 RP-221160**

**Budapest, Hungary, 6th – 9th June 2022**

## Status Report to TSG

**Agenda item:** 9.2.10

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| --- | --- |
| **WI / SI Name** | Study on further NR RedCap (reduced capability) UE complexity reduction |
| included in this status report | Study Item: Yes | Core part: No | Performance part:No | Testing part:No |
| **Acronym** | FS\_NR\_redcap\_enh |
| **Unique ID** | 940086 |
| **TSG Tdoc of latest approved WI/SI description (if any)** | [RP-213661](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_94e/Docs/RP-213661.zip) |
| **Target Completion Date****(indicate if changed)** | Study Item: 09/2022 | Core part: | Performance part: | Testing part: |
| **Overall Completion level** | Study Item: 33% | Core part: | Performance Part: | Testing part: |

**Source:**

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| **Leading WG** | RAN1 |
| **Rapporteur** | **Name** | Johan BERGMAN |
| **Company** | Ericsson |
| **Email** | johan.bergman@ericsson.com |

## 1 Work plan related evaluation

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| **Do you want to modify the time budget for this WI/SI compared to what was endorsed at the last RAN meeting?** | No |

## 2. Detailed progress in RAN WGs since last TSG meeting

## 2.1 RAN1

#### 2.1.1 Agreements

##### 2.1.1.1 RAN1#109-e

Before the meeting, 77 contributions were submitted (for details see agenda item 9.6 in [Tdoc list](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_109-e/Docs/TDoc_List_Meeting_RAN1%23109-e.xlsx)), and a workplan was provided by the SI rapporteur in [R1-2204058](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2204058.zip).

RAN1 carried out online (GTW) discussions and the following offline email discussions (with documents and agreements listed further down):

* [109-e-R18-RedCap-01] Email discussion and approval of TR skeleton
* [109-e-R18-RedCap-02] Email discussion on further UE complexity reduction
* [109-e-R18-RedCap-03] Email discussion on simulation needs and assumptions

A TR skeleton was endorsed in [R1-2205621](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2205621.zip). The related email discussion is captured in in [R1-2205431](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2205431.zip). It was furthermore agreed to arrange an email discussion (13th -17th June) on updated spreadsheet templates for collection of evaluation results.

RAN1 made the following agreements related to **study of further UE complexity reduction**:

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| --- |
| [R1-2205281](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2205281.zip)         FL summary #1 on potential solutions to further reduce RedCap UE complexity Moderator (Ericsson)[R1-2205433](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2205433.zip)         FL summary #2 on potential solutions to further reduce RedCap UE complexity Moderator (Ericsson)[R1-2205434](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2205434.zip)         FL summary #3 on potential solutions to further reduce RedCap UE complexity Moderator (Ericsson)[R1-2205435](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2205435.zip)         FL summary #4 on potential solutions to further reduce RedCap UE complexity Moderator (Ericsson)**Evaluation methodology for UE complexity reduction**Agreement:For cost reduction estimation, the detailed cost breakdown for the Rel-15 reference NR devices (as provided in Table 6.1-1 in TR 38.875) is reused.Agreement:For comparison with a Rel-17 baseline when evaluating the potential Rel-18 UE complexity reduction features,* The Rel-17 RedCap UE supports 20 MHz, 1 Rx, 1 layer, DL 64QAM, UL 64QAM, FDD or TDD.
* In addition, optional results for the following comparisons can also be reported:
	+ Results for HD-FDD UEs
	+ Results for UEs with 2 Rx
* In all comparisons, the UEs being compared have the same number of antenna branches, the same number of layers, the same maximum supported modulation order, and the same duplex mode (among HD-FDD, FD-FDD, and TDD).

Agreement:* The impact on memory size/cost/complexity (external to the RF and BB parts) from the studied UE complexity reduction features can be considered in the study.
	+ This potential impact will not be included in the quantitative UE complexity reduction estimates.
	+ L2 buffer size assumptions can be based on TS 38.306 clause 4.1.4 (“Total layer 2 buffer size for DL/UL”).
	+ FFS whether/how to capture in the TR

Agreement:For each potential Rel-18 further UE complexity reduction feature, at least the following aspects will be studied:* UE complexity reduction
* Performance impacts [details FFS]
* Network deployment and coexistence impacts [details FFS]
* Specification impacts

**Further UE bandwidth reduction**Agreement:* The following options for further UE bandwidth reduction can be studied:
	+ Option BW1: Both RF and BB bandwidths are 5 MHz for UL and DL.
	+ Option BW3: 5 MHz BB bandwidth only for PDSCH (for both unicast and broadcast) and PUSCH with 20 MHz RF bandwidth for UL and DL. The other physical channels and signals are still allowed to use a BWP up to the 20 MHz maximum UE RF+BB bandwidth.
* In addition, optional results for the following option can also be reported:
	+ Option BW2: 5 MHz BB bandwidth for all signals and channels with 20 MHz RF bandwidth for UL and DL.
* At least the following cases are studied:
	+ The resource allocation spans a bandwidth of maximum 5 MHz (Maximum UE channel bandwidth).
	+ The same option is used for UL and DL.
	+ The same option is used for idle/inactive and connected mode.
	+ It is FFS whether to study other cases.
* Note: As part of study of above options, it is not precluded to indicate that an observation is relevant for UL only or DL only.

Agreement:* For Options BW1,
	+ For 15 kHz SCS, 25 contiguous RBs are assumed to fit within the 5 MHz.
	+ For 30 kHz SCS, 11 contiguous RBs are assumed to fit within the 5 MHz.
	+ Larger number of RBs that fit within 5 MHz can optionally be studied.
* For Options BW2,
	+ For 15 kHz SCS, 25 contiguous RBs are assumed to fit within the 5 MHz.
	+ For 30 kHz SCS, 11 contiguous RBs are assumed to fit within the 5 MHz.
	+ Larger number of RBs that fit within 5 MHz can optionally be studied.
* For Options BW3,
	+ For 15 kHz SCS, 25 contiguous RBs are assumed to fit within the 5 MHz.
	+ For 30 kHz SCS, 11 contiguous RBs are assumed to fit within the 5 MHz.
	+ Larger number of RBs that fit within 5 MHz can optionally be studied.
* Relevant assumptions (e.g., regarding potential scheduling restrictions) should be reported.

**Further UE peak rate reduction**Agreement:* The following options for further UE peak rate reduction can be studied:
	+ Option PR1: Relaxation of the constraint  $(v\_{Layers}^{\left(j\right)}⋅Q\_{m}^{\left(j\right)}⋅f^{\left(j\right)}\geq 4)$ for peak data rate reduction.
	+ Option PR2: Restriction of maximum TBS for PDSCH and PUSCH.
	+ Option PR3: Restriction of maximum number of PRBs for PDSCH and PUSCH.
* At least the following cases are studied:
	+ The studied peak rate reduction applies to both UE-specific (unicast) and common (broadcast) channels.
	+ The resource allocation spans a bandwidth of maximum 20 MHz (maximum UE channel bandwidth).
	+ The same option is used for UL and DL.
	+ The same option is used for idle/inactive and connected mode.
	+ It is FFS whether to study other cases.
* Note: As part of study of above options, it is not precluded to indicate that an observation is relevant for UL only or DL only.

Agreement:* The restricted number of PRBs in Option PR3 is a hardcoded limit.

Agreement:* For Option PR1,
	+ The relaxed constraint is 1 (instead of 4).
	+ Other values for the relaxed constraint that meet the 10-Mbps peak rate target can optionally be studied.
	+ The parameters (, , ) [38.306] can be as in Rel-17 RedCap.

* For Option PR2,
	+ For 15 kHz SCS, the maximum TBS is 10000 bits per TB and per slot.
	+ For 30 kHz SCS, the maximum TBS is 5000 bits per TB and per slot.
* For Option PR3,
	+ For 15 kHz SCS, the maximum number of RBs is 25.
	+ For 30 kHz SCS, the maximum number of RBs is 11.
	+ Other number of RBs that meet the 10-Mbps peak rate target can optionally be studied.
* Note: It is not precluded to report results also for other values.
* Relevant assumptions (e.g., regarding potential limitations of the TBS sum in case of more than one simultaneous TB) should be reported.

**Relaxed UE processing timeline**Agreement:* The following options for relaxed UE processing timeline will be studied:
	+ Option PT1: Relaxation of UE processing time for PDSCH/PUSCH in terms of N1 and N2
	+ Option PT2: Relaxation of UE processing time for CSI in terms of Z and Z’
* UE complexity reduction estimates for relaxed UE processing timeline are only reported for combinations with UE bandwidth reduction or UE peak rate reduction.

Agreement:* In Option PT1, the relaxation factor for N1 and N2 is 2.
* In Option PT2, the relaxation factor for Z and Z’ is 2.
* The combination of Options PT1 and PT2 is also studied.

**Combinations of UE complexity reduction techniques**Agreement:* UE complexity reduction is studied for the following combinations:
	1. Reference case (Rel-17 RedCap UE)
	2. BW1 + PT1 + PT2
	3. BW3 + PT1 + PT2
	4. PR1 + PT1 + PT2
	5. PR3 + PT1 + PT2
* In addition, optional results for the following combinations can also be reported:
1. BW1 + PT1
2. BW3 + PT1
3. PR1 + PT1
4. PR3 + PT1
5. BW2 + PT1 + PT2
6. PR2 + PT1 + PT2
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RAN1 made the following agreements related to **simulation needs and assumptions**:

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| [R1-2205257](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2205257.zip)         FL summary #1 on simulation needs and assumptions for further reduce UE complexity Moderator (NTT DOCOMO)[R1-2205416](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2205416.zip)         FL summary #2 on simulation needs and assumptions for further reduce UE complexity Moderator (NTT DOCOMO, INC.)[R1-2205521](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2205521.zip)         FL summary #3 on simulation needs and assumptions for further reduce UE complexity Moderator (NTT DOCOMO, INC.)[R1-2205544](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2205544.zip)         FL summary #4 on simulation needs and assumptions for further reduce UE complexity Moderator (NTT DOCOMO, INC.)[R1-2205604](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2205604.zip)         FL summary #5 on simulation needs and assumptions for further reduce UE complexity Moderator (NTT DOCOMO, INC.)[R1-2205643](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2205643.zip)         FL summary #6 on simulation needs and assumptions for further reduce UE complexity Moderator (NTT DOCOMO, INC.)**Evaluation of other aspects than coverage impact**Conclusion:* SLS evaluation for network capacity and spectral efficiency is not conducted in Rel-18 RedCap SI.

Agreement:* Following evaluations are not conducted in Rel-18 RedCap SI
	+ Latency
	+ Throughput
	+ Power saving gain

Conclusion:* Evaluation of PDCCH blocking probability is not conducted in Rel-18 RedCap SI

**Evaluation of coverage impact**Agreement:* Evaluation methodology and assumption in Clause 6.3 in TR 38.875 is reused for coverage evaluation of reference UE and Rel-17 RedCap UE.
	+ Note: It is up to each company whether to reuse the LLS results

Agreement:* For coverage evaluation of Rel-18 RedCap UE, 1 Tx branch is assumed.

 Agreement:* For coverage evaluation of Rel-17 and Rel-18 RedCap UEs, only 1 Rx branch is assumed.
	+ Note: it does not mean that 2Rx is precluded for Rel-18 RedCap UE

 Agreement:* 3dB antenna efficiency loss can be optionally assumed for coverage evaluation of “Rel-18 RedCap UE with RF+BB BW reduction to 5MHz for all DL/UL channels”

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

Agreement:* The LLS results of the option of “RF+BB BW reduction to 5MHz for all DL/UL channels” can be reused for the coverage evaluation of other BW reduction options, if applicable.

Agreement:* For coverage evaluation of “Rel-18 RedCap UE with RF+BB BW reduction to 5MHz for all DL/UL channels”, following parameters are used.

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| Parameters | FR1 values |
| UE bandwidth | Rural: 5 MHz (25 PRBs, 15 kHz SCS)Urban: 5 MHz (11 PRBs or 12 PRBs (optional), 30 kHz SCS) |

* + Note: Rural scenario at 0.7 GHz, Urban scenario at 2.6 GHz, and Urban scenario at 4 GHz (optional) are considered.

 Agreement:* For coverage evaluation in Urban scenario at 4 GHz, DL PSD 33 dBm/MHz is baseline and DL PSD 24 dBm/MHz is optional.

Agreement:* For coverage evaluation of “Rel-18 RedCap UE with RF+BB BW reduction to 5MHz for all DL/UL channels”, target data rates are
	+ FR1 Rural: 250 kbps on DL and 25 kbps in UL
	+ FR1 Urban: 500 kbps on DL and 250 kbps in UL
	+ Note: The target data rates are the scaled value in the Rel-17 RedCap SI by a factor of 0.25

 Agreement:* Coverage for the following channels is evaluated for “Rel-18 RedCap UE with RF+BB BW reduction to 5MHz for all DL/UL channels”
	+ SIB1
	+ PBCH
	+ PDCCH CSS
	+ [Msg4]
	+ Following channels can be optionally evaluated
		- PUSCH
		- PUCCH 2bits
		- PUCCH 11bits
		- PUCCH 22bits
		- PRACH
		- PDSCH
		- PDCCH USS
		- Msg2
		- Msg3
* Evaluation methodology and assumption in Clause 6.3 in TR 38.875 is reused for coverage evaluation of “Rel-18 RedCap UE with RF+BB BW reduction to 5MHz for all DL/UL channels” by default, except for, UE bandwidth, cell edge data rate, and small form factor degradation
	+ FFS which evaluation assumption should be updated for the above channels

Agreement:* For SIB1 coverage evaluation of “Rel-18 RedCap UE with RF+BB BW reduction to 5MHz for all DL/UL channels”, followings are assumed
	+ Opt1: SIB1 BW is larger than 5MHz, e.g., 48PRB
		- The UE can receive a part of SIB1 PDSCH at a time. Detail assumption of reception scheme (e.g., puncturing the bits transmitted outside UE BW) is reported by each company.
	+ Opt2: SIB1 BW is within 5MHz
	+ A TBS of 1256 bits (other size is not precluded)

Note: whether interleaving mapping is assumed depends on companies’ report Agreement:* For PDCCH CSS coverage evaluation of “Rel-18 RedCap UE with RF+BB BW reduction to 5MHz for all DL/UL channels”, following revision are assumed
	+ Opt1: CORESET BW is larger than 5MHz
		- The UE can receive a part of PDCCH at a time. Detail assumption of reception scheme (e.g., puncturing the bits transmitted outside UE BW) is reported by each company.
		- For 15/30kHz SCS, CORESET size is 2 symbols and 48 PRBs, AL is 16.
		- For 30kHz SCS, CORESET size is 2 symbols and 24 PRBs, AL is 8. Other configurations are also not precluded
	+ Opt2: CORESET BW is within 5MHz
		- For 15kHz SCS, CORESET size is 3 symbols and 24 PRBs, AL is 8.
		- For 30kHz SCS,
			* Opt2-1: CORESET size is 3 symbols and 6 PRBs, AL is 2. Other configurations are also not precluded
			* Opt2-2: CORESET size is 3 symbols and 12 PRBs, AL is 4

Agreement:* For at least PDCCH USS coverage evaluation of “Rel-18 RedCap UE with RF+BB BW reduction to 5MHz for all DL/UL channels”, following revision are assumed
	+ For 15KHz SCS, CORESET size is 3 symbols and 24 PRBs, AL is 8.
	+ For 30KHz SCS,
		- Opt1: CORESET size is 3 symbols and 6 PRBs, AL is 2 (baseline)
		- Opt2: CORESET size is 3 symbols and 12 PRBs, AL is 4 (optional)

Other configurations are also not precludedAgreement:* Coverage of Msg4 can be optionally evaluated for “Rel-18 RedCap UE with RF+BB BW reduction to 5MHz for all DL/UL channels”

 Agreement:* For Msg4 coverage evaluation of “Rel-18 RedCap UE with RF+BB BW reduction to 5MHz for all DL/UL channels”, a TBS of 1040 bits is assumed
	+ a TBS smaller than 1040 bits can be optionally evaluated and reported by each company.

Agreement:* For Msg2 coverage evaluation of reference UE, Rel-17 RedCap UE, and Rel-18 RedCap UE, A TBS of 72 bits is assumed.

Agreement:* For PRACH coverage evaluation of “Rel-18 RedCap UE with RF+BB BW reduction to 5MHz for all DL/UL channels”, Format 0 is used for Rural scenario and Format B4 is used for Urban scenario
	+ Format C2 can be used optionally.

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#### 2.1.2 Remaining Open issues

Based on the SI objective in the SID ([RP-213661](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_94e/Docs/RP-213661.zip)), there are the following remaining issues:

* Study further UE complexity reduction techniques based on Rel-17 evaluation methodology in TR 38.875
	+ Consider network impact, coexistence of Rel-17 and Rel-18 RedCap and non-RedCap UEs in a cell, UE impact, specification impact
	+ Potential solutions, which may complement each other, for reducing device complexity are focusing on:
		- UE bandwidth reduction to 5MHz in FR1,
			* Possibly in combination with relaxed UE processing timeline for PDSCH and/or PUSCH and/or CSI
		- reduced UE peak data rate in FR1,
			* Possibly including restricted bandwidth for PDSCH and/or PUSCH
			* Possibly in combination with relaxed UE processing timeline for PDSCH and/or PUSCH and/or CSI
* Capture the results of the study in TR 38.865

## 4. References

RAN1#109-e

77 contributions (for details see agenda item 9.6 in [Tdoc list](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_109-e/Docs/TDoc_List_Meeting_RAN1%23109-e.xlsx))