**3GPP TSG RAN meeting #91e RP-21xxxx**

**Electronic Meeting, March 16-26, 2021**

## Status Report to TSG

**Agenda item:** 9.7.27

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| **WI / SI Name** | Support of reduced capability NR devices |
| included in this status report | Study Item: No | Core part: Yes | Performance part:Yes | Testing part:No |
| **Acronym** | NR\_redcap |
| **Unique ID** | 900062 |
| **TSG Tdoc of latest approved WI/SI description (if any)** | [RP-202933](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_90e/Docs/RP-202933.zip) |
| **Target Completion Date****(indicate if changed)** | Study Item:  | Core part:03/2022 | Performance part:09/2022 | Testing part:  |
| **Overall Completion level** | Study Item:  | Core part:10% | Performance Part:0% | Testing part:  |

**Source:**

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| **Leading WG** | RAN1 |
| **Rapporteur** | **Name** | Johan BERGMAN |
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## 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

## 2.1 RAN1

#### 2.1.1 Agreements

To the RAN1#104e meeting, 83 contributions were submitted (for details see agenda item 8.6 in [Tdoc list](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/TDoc_List_Meeting_RAN1%23104-e.xlsx)).

An initial WI work plan was provided in [R1-2100033](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100033.zip). A more detailed WI work plan will be provided after RAN#91e.

RAN1 carried out online (GTW) discussions and the following offline email discussion:

* [104-e-NR-RedCap-01] Email discussion on UE complexity reduction
	+ FL summary #1 in [R1-2101849](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Inbox/R1-2101849.zip)
	+ FL summary #2 in [R1-2101850](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Inbox/R1-2101850.zip)
	+ FL summary #3 in [R1-2101851](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Inbox/R1-2101851.zip)
	+ FL summary #4 in [R1-2101852](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Inbox/R1-2101852.zip)

A RAN1 agreement summary document capturing the RedCap RAN1 agreements listed below was submitted after the meeting in [R1-2102220](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2102220.zip). An updated version of the RAN1 agreement summary document will be submitted after every RAN1 meeting.

RAN1 made the following agreements related to **reduced maximum UE bandwidth**:

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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.

**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.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

**Conclusion:**Discuss further in RAN1#104b-e whether or not to send LS to RAN4 regarding RF retuning time, and if so, the RAN1 details associated with question.Agreements:* Study further whether and how to enable/support that PUCCH (for Msg4/[MsgB] HARQ feedback) and/or PUSCH (for Msg3/[MsgA]) transmissions fall within the RedCap UE bandwidth during initial access, with the following options:
	+ Option 1: Proper RF-retuning for RedCap (if feasible)
	+ Option 2: Separate initial UL BWP(s) for RedCap
		- FFS more than one starting PRB position
	+ Option 3: Separate PUCCH/Msg3/[MsgA] PUSCH configuration/indication or a different interpretation for the same configuration/indication for RedCap (e.g., disabled frequency hopping or different frequency hopping)
	+ Option 4: gNB configuration (e.g., always restricting the initial UL BWP to within RedCap UE bandwidth, or restrictions on the frequency location and the amount of scheduled resource for Msg4/[MsgB] HARQ feedback and Msg3/[MsgA] PUSCH)
		- As an example, with restrictions on the frequency location and the amount of scheduled resource for Msg4/[MsgB] HARQ feedback and Msg3/[MsgA] PUSCH, when the initial UL BWP is the same for RedCap and non-RedCap UEs, the PUCCH (for Msg4/[MsgB] HARQ feedback) and PUSCH (for Msg3/[MsgA]) are within the RedCap UE bandwidth
	+ Other options are not precluded
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RAN1 made the following agreements related to **reduced minimum number of Rx branches**:

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| Agreements:* For reduced minimum number of Rx branches in FR1 and FR2 frequency bands where a legacy NR UE is required to be equipped with a minimum of 2 Rx antenna ports:
	+ FFS: need for solutions to reduced PDCCH blocking
	+ FFS: need for reporting of UE antenna related information to gNB (e.g., # of panels, polarization, etc.)
	+ Information related to the reduction of the number of antenna branches is assumed to be known at the gNB (either implicitly or explicitly, to be FFS)
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RAN1 made the following agreements related to **maximum number of DL MIMO layers**:

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| 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
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RAN1 made the following agreements related to **relaxed maximum modulation order**:

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

Agreements:* The CQI tables currently defined are re-used for RedCap UEs.
	+ FFS mandatory/optional of the CQI tables
	+ There is no new CQI table to be introduced for RedCap UEs
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RAN1 made the following agreements related to **duplex operation**:

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| 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

Draft LS in [R1-2102094](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Inbox/R1-2102094.zip) is approved. Final LS to be uploaded/updated depending on whether or not there are additional agreements for RedCap related to RAN4. Final LS in [R1-2102146](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Inbox/R1-2102146.zip)Agreements:* For HD-FDD operation for RedCap UEs, collisions may be addressed or alleviated with proper scheduling. The following cases of potential collisions can be further studied to see if any change to the current specs is necessary:
	+ Case 1: Dynamically scheduled DL reception vs. semi-statically configured UL transmission
		- e.g., dynamic PDSCH or CSI-RS collides with configured SRS, PUCCH, or CG PUSCH
	+ Case 2: Semi-statically configured DL reception vs. dynamically scheduled UL transmission
		- e.g., PDCCH or SPS PDSCH collides with dynamic PUSCH or PUCCH
	+ Case 3: Semi-statically configured DL reception vs. semi-statically configured UL transmission
	+ Case 4: Dynamically scheduled DL reception vs. dynamic scheduled UL transmission
	+ Case 5: Configured SSB vs. dynamically scheduled or configured UL transmission
		- e.g., PUSCH, PUCCH, PRACH, SRS
	+ Case 8: Dynamic or semi-static DL vs. valid RO
	+ Case 9: Collision due to direction switching
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#### 2.1.2 Remaining Open issues

* Specify physical layer support for the following UE complexity reduction features.
	+ 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 40MHz 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
	+ 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.
	+ 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.
	+ 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.
	+ Duplex operation:
		- HD-FDD type A with the minimum specification impact (Note that FD-FDD and TDD are also supported.)
* Specify physical layer aspects of higher layer support of enhancements listed above.
	+ Specify definition of RedCap UE type(s) including set(s) of L1 capabilities for RedCap UE identification and for constraining the use of those RedCap L1 capabilities only for RedCap UEs, and preventing RedCap UEs from using capabilities not intended for RedCap UEs including at least carrier aggregation, dual connectivity and wider bandwidths.
	+ Specify functionality that will enable RedCap UEs to be explicitly identifiable to networks and allow operators to restrict their access if desired.
	+ Specify necessary updates of UE capabilities (38.306) and RRC parameters (38.331).

## 2.2 RAN2

The work in other WGs than RAN1 starts after RAN#91e.

## 2.3 RAN3

The work in other WGs than RAN1 starts after RAN#91e.

## 2.4 RAN4

The work in other WGs than RAN1 starts after RAN#91e.

## 4. References

RAN1#104e

83 contributions (for details see agenda item 8.6 in [Tdoc list](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/TDoc_List_Meeting_RAN1%23104-e.xlsx))