3GPP TSG-RAN WG1 Meeting #101-e Tdoc R1-20xxxxx

e-Meeting, May 25th – June 5th, 2020

**Agenda Item: 8.3**

**Title: Email discussion for Study on support of reduced capability NR devices  
(Appendix 3: Updated proposals)**

**Source: Rapporteur (Ericsson)**

**Document for: Discussion, Decision**

Contents

[Contents 1](#_Toc42236877)

[1 Introduction 2](#_Toc42236878)

[5 Requirements 2](#_Toc42236879)

[6 Evaluation methodology 2](#_Toc42236880)

[6.1 Evaluation methodology for UE complexity reduction 2](#_Toc42236881)

[6.2 Evaluation methodology for UE power saving 3](#_Toc42236882)

[6.3 Evaluation methodology for coverage recovery 3](#_Toc42236883)

[6.4 Evaluation methodology for other performance impacts 5](#_Toc42236884)

[7 UE complexity reduction features 5](#_Toc42236885)

[7.2 Reduced number of UE Rx/Tx antennas 5](#_Toc42236886)

[7.3 UE bandwidth reduction 5](#_Toc42236887)

[7.4 Half-duplex FDD operation 6](#_Toc42236888)

[7.5 Relaxed UE processing time 6](#_Toc42236889)

[7.6 Relaxed UE processing capability 6](#_Toc42236890)

[7.7 Combinations of UE complexity reduction features 6](#_Toc42236891)

[8 UE power saving and battery lifetime enhancement 6](#_Toc42236892)

[8.1 Reduced PDCCH monitoring 6](#_Toc42236893)

[9 Comments 6](#_Toc42236894)

[References 7](#_Toc42236895)

# 1 Introduction

An email discussion [101-e-NR-RedCap-01] was held during RAN1#101e for the study item “Study on support of reduced capability NR devices” [1]. The email discussion focusses on high-level topics and evaluation assumptions necessary to facilitate next step’s more concrete analysis and evaluations.

The contribution consists of the following documents:

1. ’Appendix 1: Questionnaire’ from the Rapporteur with received company comments
2. ’Appendix 2: Initial proposals’ from the Rapporteur with received company comments
3. ’Appendix 3: Updated proposals’ from the Rapporteur
4. A main document

This document is the ‘Appendix 3: Updated proposals’ document which contains updated proposals from the Rapporteur based on the comments received during the first and second steps in the email discussion which are documents in ’Appendix 1: Questionnaire’ and ’Appendix 2: Initial proposals’.

The section numbering in this document follows the proposed TR skeleton [2]. The TR skeleton itself was discussed separately in email discussion [101-e-NR-RedCap-Skeleton].

# 5 Requirements

Proposal 0: The peak bit rate requirements for industrial wireless sensors are assumed to correspond to LTE Cat-1bis (e.g. 10 Mbps peak bit rate in DL and UL).

Proposal 1: Reference bit rate is not assumed to correspond to cell-edge bit rate.

Proposal 3: The bit rates requirements indicated for smart wearable applications are assumed to correspond to high-end applications.

Proposal 4: For safety related sensors, latency requirements apply to traffic initiated from RRC\_CONNECTED.

# 6 Evaluation methodology

## 6.1 Evaluation methodology for UE complexity reduction

Proposal 5: Use the TR 36.888 methodology for UE cost/complexity evaluation as a starting point and determine what major updates are needed.

Proposal 6: Since there is no specific cost reduction target, cost/complexity estimation for the combinations of different complexity reduction techniques is down prioritized for this meeting.

Proposal 7: Cost/complexity breakdowns can be separate for FR1 and FR2.

Proposal 8: Include antenna parts at least in the cost/complexity breakdown for FR2.

Proposal 9: The reference NR device supports the following:

* All mandatory Rel-15 features (with or without capability signaling)
* Single RAT
* Band support:
  + FR1: Single band
  + FR1: Multiple bands (optional, details FFS)
  + FR2: Single band
* Maximum bandwidth:
  + For FR1: 100 MHz for DL and UL
  + For FR2: 200 MHz for DL and UL
* Duplex mode:
  + For FR1: FD-FDD
  + For FR2: TDD
* Antennas:
  + For FR1 bands {n7, n38, n41, n77, n78, n79}: 4Rx/1Tx
  + For all other FR1/FR2 bands: 2Rx/1Tx
* Power class: PC3
* Processing time: Capability 1
* Modulation:
  + For FR1: QPSK to 256QAM for DL, and QPSK to 64QAM for UL
  + For FR2: QPSK to 64QAM for DL, and QPSK to 64QAM for UL
* Access: Direct DL/UL access between UE and gNB

Proposal 10: Potential benefits in terms of reduced device size can be mentioned where applicable in the TR (e.g. in the section on reduced number of antennas), but the SI will not aim to quantify such benefits.

## 6.2 Evaluation methodology for UE power saving

Proposal 11: Reuse the power consumption models and scaling factors for FR1 and FR2 provided in TR 38.840 (sections 8.1.1, 8.1.2, 8.1.3) as appropriate.

Proposal 12: The reference UE in the power saving evaluation is a RedCap UE. Potential configuration of legacy power saving features is FFS.

Proposal 13: The power saving evaluation in RAN1 focuses on the power saving from relaxed PDCCH monitoring (whereas the power saving for the SI objectives on Extended DRX and RRM relaxation is expected to be evaluated in RAN2, and the evaluation of the power saving from other features has lower priority).

Proposal 14: For wearables, use the traffic model from TR 38.840 with proper modification of at least packet size and mean inter-arrival time for RedCap use cases. Values are FFS.

Proposal 14a: For wearables, use FTP model 3 and VoIP to characterize the RedCap service types including IM, VoIP, heartbeat, etc.

Proposal 15: For industrial wireless sensor use cases, use a traffic model based on the service performance requirements for the process monitoring use case in TS 22.104 Table 5.2-2. At least [64 bytes] message size and [100 ms] transfer interval should be considered (other values are not precluded).

## 6.3 Evaluation methodology for coverage recovery

Proposal 16: Base the coverage analysis on the IMT-2020 self-evaluation methodology.

Proposal 17: For coverage analysis, down select between the following options:

1. Align with the CE SI and perform the coverage analysis on the set of signals, channels and messages agreed to be within the scope of the CE SI.
2. Use a link budget approach taking all relevant DL and UL channels into account; including PSS/SSS, PBCH, PDCCH, PDSCH, PRACH, PUCCH, PUSCH, SIB1, Paging, RAR, Message-3, Message-4, and Message-5.

Proposal 18: Await agreements in the CE SI regarding simulation assumptions, quality targets and performance metrics before proceeding with proposals in the RedCap SI.

Proposal 19: The RedCap SI determines the “Hardware link budget” following the IMT-2020 self-evaluation methodology according to the below template, where items related to the “Maximum range” have been deleted (using track changes for traceability) and the table has been adapted to support any studied signal, channel or message (not necessarily only data and control channels).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameter** | | **Values** | | | |
| Scenario | |  | | | |
| Frame structure | |  | | | |
| Carrier frequency (Hz) | |  | | | |
| Transmission bit rate (bit/s) | |  | |  |  |
| Target packet error rate for the required SNR in item (19a) | |  | |  |  |
| Spectral efficiency (bit/s/Hz) | |  | |  |  |
| UE speed (km/h) | |  | |  |  |
| Feeder loss (dB) | |  | |  |  |
| **Transmitter** | | | |  |  |
| (1) Number of transmit antennas. (The number shall be within the indicated range in § 8.4 of Report ITU-R M.2412-0) | |  | |  |  |
| (1bis) Number of transmit antenna ports | |  | | | |
| (2) Maximal transmit power per antenna (dBm) | |  | | | |
| (3) Total transmit power = function of (1) and (2) (dBm) (The value shall not exceed the indicated value in § 8.4 of Report ITU-R M.2412-0) | |  | | | |
| (4) Transmitter antenna gain (dBi) | |  | | |  |
| (5) Transmitter array gain (depends on transmitter array configurations and technologies such as adaptive beam forming, CDD (cyclic delay diversity), etc.) (dB) | |  | | |  |
| (6) Channel power boosting gain or loss (dB) |  | | | |  |
| (8) Cable, connector, combiner, body losses, etc. (enumerate sources) (dB) (feeder loss must be included for and only for downlink) |  | | | |  |
| (9a) EIRP = (3) + (4) + (5) + (6) – (8) dBm |  | | | |  |
| **Receiver** | | | | |  |
| (10) Number of receive antennas (The number shall be within the indicated range in § 8.4 of Report ITU-R M.2412-0) |  | | | |  |
| (10bis) Number of receive antenna ports |  | | | |  |
| (11) Receiver antenna gain (dBi) |  | | | |  |
| (11bis) Receiver array gain (depends on transmitter array configurations and technologies such as adaptive beam forming, etc.) (dB) |  | | | |  |
| (12) Cable, connector, combiner, body losses, etc. (enumerate sources) (dB) (feeder loss must be included for and only for uplink) |  | | | |  |
| (13) Receiver noise figure (dB) |  | | | |  |
| (14) Thermal noise density (dBm/Hz) |  | | | |  |
| (15a) Receiver interference density (dBm/Hz) |  | | | |  |
| (16a) Total noise plus interference density = 10 log (10^(((13) + (14))/10) + 10^((15a)/10)) dBm/Hz | |  |  |  |  |
| (17a) Occupied channel bandwidth (for meeting the requirements of the traffic type) (Hz) | |  |  |  |  |
| (18a) Effective noise power = (16a) + 10 log((17a)) dBm | |  | |  |  |
| (19a) Required SNR (dB) | |  | |  |  |
| (20) Receiver implementation margin (dB) | |  | |  |  |
| (21a) H-ARQ gain (dB) | |  | |  |  |
| (22a) Receiver sensitivity = (18a) + (19a) + (20) – (21a) dBm | |  | |  |  |
| (23a) Hardware link budget = (9a) + (11) + (11bis) – (22a) dB | |  |  |  |  |

Proposal 20: Add one final row supporting the calculation of the maximum coupling loss (MCL), which is defined as the total transmitted power minus receiver sensitivity, as measured at the antenna connectors, i.e. = (3) + (6) - (22a).

## 6.4 Evaluation methodology for other performance impacts

Proposal 21: The evaluation of performance impacts includes at least peak data rate and latency. Other performance metrics such as power consumption and spectral efficiency are not precluded.

# 7 UE complexity reduction features

## 7.2 Reduced number of UE Rx/Tx antennas

Proposal 22: For FR1, study two antenna configurations for RedCap UEs, namely 1Rx/1Tx and 2Rx/1Tx.

Proposal 22a: For FR1, potential reduced antenna radiation efficiency due to device size limitations for wearables can be reported as part of the antenna gains in the coverage analysis.

Proposal 23: For FR2, study two antenna configurations for RedCap UEs, namely 1Rx/1Tx and 2Rx/1Tx, where study of 2Rx/1Tx is prioritized.

## 7.3 UE bandwidth reduction

The following agreement was made in a RAN1#101e GTW online session:

|  |
| --- |
| Agreements:   * For FR1, study at least 20MHz maximum UE bandwidth at least for initial access   + Other bandwidths FFS * For FR2, study 50MHz and 100 MHz maximum UE bandwidth at least for initial access   + Other bandwidths FFS |

Proposal 24a: For FR1, study potential issues with supporting FDMed ROs spanning a larger bandwidth than the UE bandwidth.

Proposal 25a: For FR2, study potential issues with supporting SSB/CORESET#0 multiplexing patterns spanning a larger bandwidth than the UE bandwidth.

## 7.4 Half-duplex FDD operation

Proposal 26: Study HD-FDD operation Type A and Type B, where study of Type A is prioritized.

Proposal 27: Let RAN4 determine the values of DL-to-UL and UL-to-DL guard periods, if needed.

## 7.5 Relaxed UE processing time

Proposal 28: Study a more relaxed UE processing time in terms of N1/N2 compared to capability #1, including the impacts on cost/complexity, power saving, latency and scheduling flexibility (at least qualitatively).

Proposal 29: Study relaxed CSI computation time as a complexity reduction technique through relaxed UE processing time with low priority.

## 7.6 Relaxed UE processing capability

Proposal 30: Study peak data rate relaxation and focus at least on:

* Maximum modulation order restriction
* Reducing the maximum number of MIMO layers

## 7.7 Combinations of UE complexity reduction features

Proposal 32: Discussion on combinations of UE complexity reduction features is down prioritized till the next meeting.

# 8 UE power saving and battery lifetime enhancement

## 8.1 Reduced PDCCH monitoring

Proposal 33: Study the impact of BD and CCE limits reduction on power saving and PDCCH blocking probability (quantitatively) and impacts on latency and scheduling flexibility (at least qualitatively).

# 9 Comments

|  |  |  |
| --- | --- | --- |
| **Company** | **Proposal** | **Comments (major concerns)** |
| Qualcomm | 3 | We think the low-end wearables can be further studied for RedCap UE, and would suggest to keep it in the scope of this SI. If there is no census yet for the bit rates requirements of low-end wearables, it can be further discussed at RAN-P and clarified in the SID. |
| 5 | * Band Support   + we have concerns to include “multiple bands” for reference device deployed in FR1, since it potentially increases the load of evaluation and is not a mandatory UE capability for NR Rel-15/16. * Modulation   In addition to the max modulation order, we think the MCS tables supported by the reference UE on DL/UL need to be clarified for the analysis of peak data rates and reference bit rates. |
| 16 and 18 | * We think the link budget template used for coverage evaluation of RedCap UE should be clarified in these proposals (e.g. new entries associated with compact form factor should be modeled for RedCap UE, which may not be included in IMT2020 template or the template used by CE SI) * In addition, could you please clarify if “coverage analysis” has the same meaning as “coverage evaluation” in Proposal 16 ? |
| OPPO | 0 and 3 | Referring the 36.306, the LTE cat 1bis is around 10 Mbps in DL and 5Mbps in UL. Thus the proposal 0 would be higher than 1bs for UL. With the “(e.g. 10 Mbps peak bit rate in DL and UL)”.  We also think the low-end wearable should be not excluded in the study. Not sure if removing it is due to the SID, e.g. it may be lower than cat 1bis. If we 10 Mbps in DL and 5Mbps in UL for low-send wearable, it would be ok. |
| 19 and 22a | In 19, we should also include the link budget entries in the table for compact form factors into the template as the proposal 22a  The wording of 22a should be changed back to “reflected as part of the antenna gains in the coverage analysis”. We should remove “potential”.  Since it is clear that the form factor will impact the antenna gain. The only matter is exactly number. At least 3 dB should be considered. |
| vivo | 3 | Low-end wearables are important use cases for RedCap thus no reason for exclude it. The use cases and requirements in SID justification parts are only examples and the objective section does not say we cannot consider any other use cases beyond these examples. From the collected views, 17 companies supported to include low-end wearables into the study. Some companies would like to have more time to check the data rate requirements for low-end wearables, this is fine but we should first confirm the use case and can leave the detailed data rate values in bracket for further check.  Suggest to revise proposal 3 as  Proposal 3: The bit rates requirements indicated for smart wearable applications are assumed to correspond to high-end applications. For low-end wearables, lower bitrates can be assumed, e.g. [2-5 Mbps] reference bit rate in DL and UL and [10 Mbps] peak bit rate in DL and UL. |
| 9 | Two concerns with proposal 9   1. As commented before, several mandatory with capability signaling features has not been implemented yet even for normal UEs, it is not reasonable to assume a reduced complexity UEs will support these features for sure. Therefore these feature has to be discussed case by case, if necessary. 2. In the duplex mode for FR1, both FD-FDD and TDD should be included.   Suggest the following revisions to Proposal 9:  Proposal 9: The reference NR device supports the following:   * All mandatory Rel-15 features ~~(with or without capability signaling)~~ * Single RAT * Band support:   + FR1: Single band   + FR1: Multiple bands (optional, details FFS)   + FR2: Single band * Maximum bandwidth:   + For FR1: 100 MHz for DL and UL   + For FR2: 200 MHz for DL and UL * Duplex mode:   + For FR1: FD-FDD, TDD   + For FR2: TDD * Antennas:   + For FR1 bands {n7, n38, n41, n77, n78, n79}: 4Rx/1Tx   + For all other FR1/FR2 bands: 2Rx/1Tx * Power class: PC3 * Processing time: Capability 1 * Modulation:   + For FR1: QPSK to 256QAM for DL, and QPSK to 64QAM for UL   + For FR2: QPSK to 64QAM for DL, and QPSK to 64QAM for UL * Access: Direct DL/UL access between UE and gNB |
| 12 | Based on the current formulation, the proposal 12 seems not quite meaningful. |
| 13 | Power saving benefit will be an important metric for many of other features, for example the reduced Rx antenna, reduced bandwidth, relaxed UE processing time, etc. For a particular feature, if power saving benefit is significant, it should be considered even if the cost/complexity reduction may not be large. Note that we have power consumption analysis in each of the techniques captured in TR36.888, we expect similar study should be carried out in RedCap.  Suggest the following revisions to proposal 13  Proposal 13: The power saving evaluation in RAN1 focuses on the power saving from relaxed PDCCH monitoring (whereas the power saving for the SI objectives on Extended DRX and RRM relaxation is expected to be evaluated in RAN2, and the evaluation of the power saving from other features ~~has lower priority~~ is not precluded). |
| 17 | We think it should be able to select option 2 already as it is clearly favoured by most of companies based on the feedback. |
| 21 | As said before, power consumption is an important metric for all most of the features discussed in RedCap SI, however, such metric seems to be deprioritized by the current wording which is unacceptable.  Suggest the following revision  Proposal 21: The evaluation of performance impacts includes at least power consumption, peak data rate and latency. Other performance metrics such as spectral efficiency are not precluded. |
| 22 | Generally fine, but we think we should try to align the assumptions for antenna efficiency loss as much as possible, in order to have comparable evaluation results. Therefore it should be defined as part of evaluation assumption discussion in the next step, rather than reported by each company.  Suggest the following small update.  Proposal 22a: For FR1, potential reduced antenna radiation efficiency due to device size limitations for wearables can be defined as part of the antenna gains in the coverage evaluation assumptions. |
| 30 | It is still not clear to us why reduced HARQ process number is not considered. In general less buffer is required if reduced capability UE is allowed to support much less number of HARQ processes. |
| Samsung | 3 | We also think low-end wearable use case can be considered in this SI. |
| 6, 18, 32, 29 | There is no need to agree on a proposal to say we downprioritized something for this meeting in the last day. (Proposal 6, 18, 32)  No need to agree on something with low priority. That is, unless we study and agree to capture a feature, there is no need to mention it in TR. (Proposal 29) |
| 9 | In general, for the reference NR device, it should be one simple reference device other than create multiple references. It would increase the effort of the study and evaluation. Therefore, we suggest to remove the following parts   1. Delete “FR1: Multiple bands (optional, details FFS)”—> not essential and had to converge 2. Delete “For FR1 bands {n7, n38, n41, n77, n78, n79}: 4Rx/1Tx ”🡪 This is not necessary to create multiple options for each assumption. We can make some observation on % of cost increase with 4Rx, if needed. |
| 12 | No need to consider legacy power saving features. No benefit and it increases evaluation overhead. Reduction on PDCCH monitoring can be applied independently to any legacy power saving features.  Proposal 12: The reference UE in the power saving evaluation is a RedCap UE. ~~Potential configuration of legacy power saving features is FFS.~~ |
| 14 | Proposal 14a is enough, proposal 14 can be removed. |
| 17 | We don’t agree to down scope between these two options. We are not clear on what’s CE SI will agree in option 1. And we don’t think all the UL/DL channels in option 2 needs to be evaluated. |
| 19, 20 | OK in principle, but we need more time to check and also try to align with output of CE SI. |
| 24a, 25a | Further clarification is needed for the proposal. In addition, we think this belongs to one of potential impacts on BW reduction. We don’t think need to list this one specially. |
| Xiaomi | 3 | Low-end wearables can be further studied and it may be discussed in the coming RAN plenary on the SID. |
| 23 | Since the two configurations are both studied, we do not think priority should be defined. |
| 27 | We have concerns on the exact meaning of “guard period”. Could the rapporteur clarify whether this “guard period” considers the impact of timing advance? In addition, there may be different definition of “guard period”. For example, in LTE HD-FDD UE, the guard period is defined as period(s) before and after (only for Type B) UL transmission. However, for NR UE not capable of full-duplex, guard period is defined as periods after UL transmission and after DL reception. Could the rapporteur clarify what is the definition of “guard period” in the proposal? |
| MediaTek | 3 | We don’t see a need for Proposal 3.  From RAN1 perspective, there is no difference in calling the use-case as “wearables” or “high-end wearables”.  If there is a need to change the use-cases, this is something can be done in RAN plenary. |
| 16 | We don’t see that the coverage analysis need be solely based on the IMT-2020 self-evaluation methodology.  As the SID scope is to recover coverage loss due to complexity-reduction features, the methodology should focus on the relative metrics with respect to the reference NR. For this purpose, a simplified link-level simulation can be used. |
| 17 & 18 | No need to evaluate the channels that are not impacted by the complexity reduction features.  No need to wait for CE SI, we can evaluate PDCCH based on simplified link-level simulation first. |
| 21 | Other system performance impact shouldn’t be excluded, such as PDCCH blockage probability. |
| 22a | We can’t accept this proposal.  The SID scope is to recover coverage loss due to complexity-reduction features:  “*Coverage recovery to compensate for potential coverage reduction due to the device complexity reduction*”.  The impact of antenna’s radiation efficiency due to device size limitations is not part of the SID scope. |
| FUTUREWEI | 0,1,3,4 | Can accept, but are **not essential** and should not be part of email discussion if not agreed. Adding a 4th use case for low end wearables is for RAN, not here. |
|  | 5,6,7,8,9  10 | 5-9 are **essential** for next meeting, should have email discussion if not agreed today. Should add to proposal 9 preamble that this reference UE is for “evaluation of complexity reduction”. We should avail ourselves of all mandatory and optional power savings and coverage recovery features in rel-15 and -16 before developing new ones. This can be part of the final recommendation. For 9, multiple bands should remain as ‘optional’…it is important to be able to make statements before final recommendations if some techniques have gains that accumulate across multiple bands (or not).  10 is **nice to have** but can wait if controversial |
|  | 11,12,13,14,14a,15  33 | These would be **good to have** for next meeting, so OK to be part of email discussion if cannot converge today. Also OK to wait as scope of power savings may be discussed in RAN. |
|  | 16,17,18,**19**,20, 21 | These are **not essential**, as (a) compensating for techniques can wait until we progress the techniques, (b) we should not duplicate or deviate from the cov enh SI. So if not agreed today should not be part of email discussion.  16-18,20, 21 can accept. **19 is too soon** as it assumes one option for 17. |
|  | 22,23  24a 25a  26, 27, 28, 29, 30, 32 | It is **essential** to have some agreements on reduced antenna, if 22 and 23 are not agreed should be part of email discussion. 22a is nice to have but can wait if not agreed today.  Already made progress on BW reduction, 24a 25a are nice to have but should not be part of email discussion if not agreed.  26-32 are nice to have but not be part of email discussion if not agreed. Nothing further is acceptable in 30, can discuss in RAN as needed. |
|  |  |  |
|  |  |  |

# References

[1] [RP-193238](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_86/Docs/RP-193238.zip), ”New SID on support of reduced capability NR devices”

[2] [R1-2003288](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003288.zip), “TR skeleton for Redcap”, Rapporteur (Ericsson)