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 (Step 2)**

**Source: Rapporteur (Ericsson)**

**Document for: Discussion, Decision**

Contents

1 Introduction 2

5 Requirements 2

6 Evaluation methodology 3

6.1 Evaluation methodology for UE complexity reduction 3

6.2 Evaluation methodology for UE power saving 7

6.3 Evaluation methodology for coverage recovery 9

6.4 Evaluation methodology for other performance impacts 13

7 UE complexity reduction features 14

7.1 Introduction to UE complexity reduction features 14

7.2 Reduced number of UE Rx/Tx antennas 14

7.3 UE bandwidth reduction 15

7.4 Half-duplex FDD operation 16

7.5 Relaxed UE processing time 17

7.6 Relaxed UE processing capability 18

7.7 Combinations of UE complexity reduction features 19

8 UE power saving and battery lifetime enhancement 19

8.1 Reduced PDCCH monitoring 19

9 Other comments 20

References 21

# 1 Introduction

This document captures the 2nd step of the RAN1#101e email discussion [101-e-NR-RedCap-01] for the study item “Study on support of reduced capability NR devices” [1]. This email discussion focusses on high-level topics and evaluation assumptions necessary to facilitate next step’s more concrete analysis and evaluations.

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

# 5 Requirements

Regarding Question 1, most responses indicate that the requirements are generally sufficiently clear, but some clarifications are proposed. The proposals supported by more than one individual response are the following:

* Clarify peak rates for all use cases.
* Clarify that the reference bitrate is typical bitrate and not the cell-edge bitrate.
* Add cell-edge bit rate requirements.
* Add requirements for low-end wearables.
* Clarify that the 5-10 ms latency requirement for safety-related sensors should be considered for UEs in RRC\_CONNECTED.

Based on the proposals listed above, the following proposals can be considered.

**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).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| Rapporteur (Ericsson) |  | Proposal 0 is added in ‘RedCap01a-v003-LG-Rapporteur’ based on this comment from LG in ‘RedCap01a-v002-LG’:  *ZTE, Qualcomm, Samsung, LG, Sequans, and InterDigital commented in favour of this. We propose to add a proposal for clarifications on peak rates. The proposal could be similar to the Proposal 3.*  ***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).***  *We think 10Mbps for IWS is a bit overkill. But, as we agreed to not consider the data below LTE Cat 1bis, we assumed 10Mpbs should be supported for all redcap devices.* |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | N (but ok) | We have 2Mbps for the industrial wireless sensor, should be good enough. It seems odd to create “fake” traffic models that may not be needed by agreeing now to cell-edge/typical/peak data rates. If needed can discuss peak data rates later for these sensors. But for evaluations, we could probably use the data rate in the SID as whatever cell-edge/cell-avg/peak rate, as the e.g. “alarm” contents should be available everywhere.  NOTE: it is weird to mix together an argument for application traffic and for the minimum reduced capability device we can study. |
| SONY | Y | We agree that the data rate for IWS devices is likely to have a maximum of about 2Mbps, but we are OK with the 10Mbps peak rate, given we agreed to not consider a data rate below LTE Cat 1bis. |
| InterDigital | Y |  |
| DOCOMO | Y |  |
| Intel | Y |  |
| vivo | Y |  |
| Samsung | Y |  |
| Xiaomi | Y |  |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y |  |
| LG | Y |  |
| Huawei, HiSilicon | Partially Yes | However we want to emphasize that one of the objective is to consider limited sets of device types, therefore it may not be desirable to set many different requirements with finer granularity but providing litter difference from cost/complexity saving perspective. The principle (as also provided in SID) that the requirement of no less than LTE Cat 1bis set a bottom line for RedCap UEs across all three use cases can be something that we need to keep in mind, but should not be used for justifying a lower end device with the possible lowest requirement. |

**Proposal 1: Reference bit rate is assumed to correspond to typical (i.e. median) bit rate, not cell-edge bit rate.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y |  |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | N (but ok) | See above comment on an “alarm” sensor, which may also apply to a video feed for the surveillance application. May be OK for wearables. |
| SONY | N | “Reference bit rate” meaning “median bit rate” raises too many questions.   * Median over what? Is the idea to do some SLS, work out the median SINR and then calculate a data rate? Is this saying that there are 100 codecs and the 50%-ile codec requires the “reference bit rate” * For IWSN (which quotes TS22.104), why is the median data rate equal to the maximum data rate in TS22.104 (2Mbps)? For median = maximum, don’t all devices need to be operating at the same data rate (= maximum data rate). Given that in TS22.104 there are three data rates for IWSN with service data rates of up to 1Mbps, 200kbps, 2Mbps, why is the median data rate equal to the maximum of these data rates? * For wearables, what does median bit rate is a minimum of 5Mbps in UL mean?   The literal understanding of the reference bit rates would be that these are the application bits rates. If they are the application bit rates, then they need to be supported at the cell edge (but supporting 25Mbps in the UL (for high-end video) at the cell edge looks implausible).  Maybe “reference bit rate” means something like “desired peak rate capability for the device” |
| InterDigital | Y |  |
| DOCOMO | Y | The reference bit rate does not have to be met in cell-edge |
| Intel | Y |  |
| Samsung | Y |  |
| Xiaomi | Y |  |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y |  |
| Huawei, HiSilicon | Y |  |

**Proposal 2: There is no need to introduce new requirements on cell-edge bit rate, as cell-edge bit rates will be determined as part of the simulation assumptions.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y |  |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y with modification to drop second half of the proposal |  |
| SONY | N | The statement “*as cell-edge bit rates will be determined as part of the simulation assumptions*” does not seem to be correct. There do not seem to be simulation assumptions in the evaluation methodology covering cell-edge bit rates (or is it that this aspect of simulation methodology will be discussed at RAN1#102e?).  If the reference bit rates are not cell-edge bit rates, we are happy to not introduce cell-edge bit rates. Cell-edge performance would then be on a best-effort basis. |
| InterDigital | Y |  |
| DOCOMO | - | We are open whether the required/target cell-edge bit rate is defined in this clause or in the simulation assumptions |
| Intel | Y | We are fine to not introduce new requirements for cell-edge data rates as long as clear data rate targets are identified as part of evaluation assumptions. |
| vivo | Y |  |
| Samsung | Y |  |
| Xiaomi |  | Firstly, we suggest to clarify the purpose of defining the cell-edge bit rate and how to define it, e.g., from the minimum requirement of service or according to 5% UE throughput  If it is used for the coverage evaluation, we are OK to define it. |
| TCL | Y |  |
| China Telecom | Y |  |
| Huawei, HiSilicon | FFS | UL coverage is crucial for practical networks, therefore, uplink cell-edge bit rates as a requirement is essential. |

**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.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG |  | In terms of required bit rates, the low-end wearables are similar to the sensors for IWS applications. One outstanding difference b/w the two may be the full mobility support for low-end wearables, but what about other requirements? Perhaps the low-end wearables require the battery lifetime much long than the high-end wearables? In our view, we need to further discuss the target use cases for the low-end wearables to come up with the corresponding use case specific requirements including the peak bit rates that we are trying to assume with this proposal. |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | N | The SID is already bursting with things to do, RAN1 should not add a fourth use case however interesting. SID revision can be proposed in RAN. |
| SONY | N | Yes, te current requirements for wearables (10-50Mbps DL etc) seem to be for high-end wearables.  -Low-end wearables would have data rates similar to IWSN.  -A “normal” wearable might have peak UL, DL data rates of 10Mbps.  Our understanding of the peak data rate for wearables is motivated by UE being able to save power if it can sleep sooner (receive / transmit data at a high rate and then sleep sooner). In this case, RAN1 should not include devices features into Redcap that would have the effect of increasing power consumption if the goal of those features were to increase peak rates, |
| InterDigital | Y |  |
| Spreadtrum | Y | Add requirements for low-end wearables. |
| DOCOMO | Y | SID refers various types of wearable devices, i.e. not only smart watches but also rings, eHealth related devices, and medical monitoring device. In the sense, it is natural to consider low-end wearables in addition to high-end one. It is noted that even if we define such additional use case for low-end wearables, we do not have to define additional sets of UE features. In other words, it is still FFS whether only one set of UE feature may cover all the RedCap use cases. |
| Intel |  | It is not clear if the proposal is to introduce a new set/combination of QoS requirements for a new class of devices. If so, should this not be discussed as part of the SID update?  On the other hand, we could agree to such characterization as long as it is clarified that we expect that these requirements are expected to be fulfilled by the targets identified for the existing three classes. In short, we do not think we should expand the scope of the study, at least as part of the current discussion. |
| vivo | Y | Low-end wearables are very typical/popular use cases therefore should be included in Redcap study to address the market needs. We think adding low-end wearable scenario does not expand the SI scope, as the data rate requirement is very similar to industrial sensors as currently included in the study. |
| Samsung | Y |  |
| Xiaomi |  | Agree to discuss the reference bit rate for lower-end wearable devices. But we suggest to conclude the exact value in next meeting. |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | N (Y for first sentence) | We don’t see the need to address low-end wearables in this SI. The mentioned lower bitrates can be addressed by existing devices up to Cat1-bis. |
| Huawei, HiSilicon | No | We are concerned to have too different/separate requirements within a single use case which further split the implementation and market. |

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y |  |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y | This type of sensor may need bigger batteries |
| SONY | Y |  |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| DOCOMO | Y | Same as URLLC latency requirement, the latency requirement of safety related sensors applies to the UE in RRC\_CONNECTED state |
| Intel | Y |  |
| vivo | Y |  |
| Samsung | Y | In addition, we like to clarify that it is not required to support all the bullets in the same time for one use case. |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y |  |
| Huawei, HiSilicon | Y | For safety related sensors, reliability is 99.99%~99.999% and latency requirement is lower, 5-10 ms end-to-end latency (Note: 3-8 ms air interface latency). |

# 6 Evaluation methodology

## 6.1 Evaluation methodology for UE complexity reduction

Regarding Question 2, most responses seem to agree that the UE cost/complexity reduction evaluation methodology in TR 36.888 can be used as a starting point or baseline that can be updated to take FR1/FR2 specific aspects and technology progress into account.

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | Based on the methodology in TR 36.888, the differentiating factors in NR such as target peak bit rates, range of UE bandwidth, considerations on FR2, etc., can be updated. |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y |  |
| SONY | Y | Furthermore, need to consider whether different cost / complexity reduction features should be applied to the different use cases (e.g. presumably video surveillance cameras wouldn’t need to implement a small form factor antenna technique targeted at wearables). |
| InterDigital | Y |  |
| Spreadtrum | Y | The major updates could be: a) Relaxed processing time/capability. b) Relaxed PDCCH monitoring capability. |
| DOCOMO | Y |  |
| Intel | Y |  |
| vivo | Y |  |
| Samsung | Y |  |
| Xiaomi | Y |  |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y | Update could consider:   * higher bandwidth, BWP operation, larger number of HARQ processes, new modulations, new error correction codes * capability aspects related to latency/reliability targets which are missing from LTE MTC study   breakdown between baseband and RF cost, as well as a separate cost structure for FR1 and FR2 RF |
| Huawei, HiSilicon | Yes | The methodology in TR 36.888 can be regarded as the baseline for the analyses in FR1 in view of the similar design and characteristics especially in low frequency band. |

One response points out that there is no specific cost reduction target (unlike when TR 36.888 was produced) and therefore precise cost estimation may not be necessary. Some responses seem to suggest that a simplified approach with only rough cost estimates may be enough. (See also the related discussion in section 7.7 in this document.)

**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.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | We would like to note that the cost reduction target can be different depending on the target use case. |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y | Agree there is no specific target for any use case. This can be down-prioritized until after we have progress on the main individual techniques further. |
| SONY | Y | Complexity estimation for combinations of techniques is down prioritized in the SI, not just at this meeting. |
| InterDigital | Y |  |
| Spreadtrum | Y | For simplicity, we need to decide how many features need to be studied first and then consider the combination. |
| DOCOMO | Y |  |
| Intel | Y |  |
| vivo | Y | There is no strong need to explicitly study the cost/complexity estimation for the combination of different complexity reduction techniques. However, it can be discussed for each complexity reduction technique if it may have some conflict with other techniques. However, given the very limited time, it should be de-prioritized in the whole SI. |
| Samsung | Y | OK to the proposal in general. But here is no need to make as an agreement. |
| Xiaomi | Y |  |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans |  | Could agree for the cost estimation but not necessarily about the complexity. We should be able to evaluate the complexity reduction from the combinations of different proposed techniques, e.g. N1/N2 relaxation together with PDCCH monitoring relaxation, or if there is conflict. |
| Huawei, HiSilicon | Yes |  |

Regarding Question 3, most responses seem to agree that antenna parts should be included in the cost/complexity evaluation for FR2. Some responses list potential aspects of antenna parts or antenna-near parts, e.g. ADC/DAC, PAs, filters, beamforming network, polarization, antenna panels and antenna panel elements. A few responses want to include the antenna parts also in FR1.

Several responses propose to define separate reference modems with separate cost breakdowns for FR1 and FR2. Among the aspects that are expected to differ between FR1 and FR2 are the mentioned antenna parts and the impacts of different subcarrier spacings.

**Proposal 7: Define separate reference modems with separate cost/complexity breakdowns for FR1 and FR2.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y |  |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | N (but may be ok if reformulated) | Not sure why this is needed on top of proposal 5, which has us start with “888” and make modifications for FR1/FR2 as needed. For example. “888” can be used for FR1 with appropriate list of caveats. FR2 we can discuss in parallel additional elements as we progress antenna reduction, BW reduction etc so we have an idea of the cost when time to make recommendations. So perhaps the proposal really is whether there can be FR2 specific modifications to the 888 baseline. For that we agree (Y). |
| SONY | Y | The features of FR1 and FR2 devices seem quite different in various respects. We envisage that some devices will support FR1, but not FR2, or vice versa. Hence separate cost / complexity breakdowns seem appropriate. |
| InterDigital | Y |  |
| Spreadtrum | Y | The number of RF chains in FR2 may be less than that in FR1. |
| DOCOMO | Y | As the RF components of FR2 is quite different from those of FR1, it is preferred to define separate reference modems with separate cost/complexity breakdowns for FR1 and FR2 |
| Intel | Y |  |
| vivo | Y |  |
| Samsung | Y or N | The cost/complexity breakdowns of baseband is expected to be same for FR1 and FR 2, but RF and antenna may have some different. For baseband part, we prefer to use same cost/complexity breakdowns but allowing different percentage of each component. |
| Xiaomi | Y |  |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y | We should consider separate cost structure for FR1 and FR2 RF. UE antennas cost should be included in the analysis for FR2. |
| Huawei, HiSilicon | Yes | However, we should also not spend much time to discuss FR2 specific techniques. |

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y |  |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y | Can do in parallel |
| SONY | Y | Single polarized UE antenna can be an option to reduce processing in UE. |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| DOCOMO | Y |  |
| Intel | Y |  |
| vivo | Y |  |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y |  |
| Huawei, HiSilicon | FFS | It is not so clear whether the proposal is to make decision on whether antenna parts have to be differentiated, i.e. to conclude that reduction of antenna parts is one of the candidate techniques? |

Regarding Question 4, the responses can be summarized as follows:

* **Features:** Most responses seem to agree that the reference NR device should correspond to an NR UE that supports all mandatory Rel-15 NR features including mandatory features with capability signaling. A few responses suggest including some Rel-16 features for e.g. power saving and positioning or excluding some mandatory features with capability signaling.
* **RATs:** A few responses propose that the reference device only supports one RAT, i.e. NR.
* **Bands:** Some responses propose that the reference NR devices should support a single band, whereas one response proposes that it supports multiple bands (e.g. FDD band 14 + TDD band 10).
* **Bandwidths:** Many responses propose 100 MHz for FR1 and 200 MHz for FR2. A couple of responses propose that the maximum bandwidth supported by the reference NR device should be the maximum bandwidth supported for the band, e.g. 70 MHz for FR1 FDD, 100 MHz for FR1 TDD, and 400 MHz for FR2. One response proposes that the reference NR device also supports the smaller bandwidths supported for the band.
* **Duplex modes:** One response proposes to only define reference NR devices for FR1 FDD and FR2 TDD, not for FR1 TDD, with the motivation that the cost difference between FR1 FDD and FR1 TDD can be expected to be small.
* **Antennas:** The responses mention 4Rx/2Tx, 4Rx/1Tx and 2Rx/1Tx. Some responses point to the minimum requirements in TS 38.101 and propose 4Rx/1Tx for FR1 bands {n7, n38, n41, n77, n78, n79} and 2Rx/1Tx for all other FR1/FR2 bands.
* **Power class:** A few responses propose to assume UE power class 3 (PC3).
* **Processing time:** A few responses propose to assume UE processing time capability 1.
* **Modulation:** A few responses propose that the reference NR device supports up to 64QAM in DL and UL. One of them thinks that 256QAM can also be considered in DL.
* **Access:** A couple of responses propose to clarify that access is direct DL/UL access between UE and gNB.

Furthermore, one response proposes to also define a reference NR device with 2Rx/1Tx and 20 MHz in order to have a reference NR device that matches LTE Cat-1 which was used as a reference LTE device in TR 36.888.

**Proposal 9: The reference NR device supports the following:**

* **All mandatory Rel-15 features (with or without capability signaling)**
* **Single RAT**
* **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: QPSK to 64QAM for DL and UL**
* **Access: Direct DL/UL access between UE and gNB**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | Basically okay as it is, but including the 256QAM for DL would be helpful to at least check the potential cost/complexity reduction that can be achieved by restricting the max modulation from 256QAM to 64QAM. |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y | Sierra made a very good point some practical devices may support multiple bands. Having this as a reference may be ok, but we should note where applicable that the benefits for certain techniques accumulate over all the supported bands. In some cases, baseband reductions may become less attractive. We can take this into account when making final recommendations. |
| SONY | Y |  |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| DOCOMO | Y |  |
| Intel | Y |  |
| vivo | N | On the first bullet, several Rel-15 mandatory with capability signaling features has not been implemented yet, they should not be considered as supported by the reference NR devices. We suggest to only consider the “mandatory without capability signaling” features for the reference NR devices, and “mandatory with capability signaling” features should be discussed case by case.  The last bullet can be removed, there is no direct impact to the Redcap design. |
| Samsung | Partially Y | For simplification, 2Rx can be choses for FR 1 as the reference NR device. Some potential impacts can be provided for FR1 bands required to have 4Rx. |
| Xiaomi | Y |  |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y for most points, but not all | Single band is easier for the analysis but if proposal 30 is agreed, then maybe the reference device should support CA. In that case, reducing the number of CC may be as well a good way to reduce cost/complexity.  We should also consider for the reference NR device:   * Processing time Capability #2. Including also this capability will be useful to at least get a good idea on cost/complexity reduction that can be achieved when moving to capability #1 * 256 in DL – same reason as above * support of optional features related to targeted use cases, e.g. power saving and positioning. |
| Huawei, HiSilicon | Agree all except single band | Multi-band phone is typical, so at least TDD and FDD duplexing modes should be considered.  We propose   * **Single band and two bands (one FDD band below 2.5GHz and one TDD band above 2.5GHz)** |

Regarding Question 5, many responses acknowledge that there may be important benefits in terms of device size or form factor, but most responses seem to agree that there is no need to try to quantify the potential reduction in device size. Perhaps a reasonable ambition level is to mention such benefits in the TR clauses where they are most prominent, e.g. when discussing reduced number of antennas.

**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.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | May be hard to quantify the benefits, but the compact form factor itself is one of the generic requirements that need to be achieved by all use cases. So, it deserves being mentioned in the TR. |
| Ericsson | Y | It is enough to list the potential benefits in terms of device size reduction in the existing subsections on “Analysis of UE complexity reduction” in clause 7 wherever applicable. |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y |  |
| SONY | Y | Small form factor is important. Agree that could be hard to quantify benefits of small factor. Maybe it is also hard to quantify drawbacks (e.g. due to loss of antenna efficiency). |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| DOCOMO | Y | It is enough to mention the potential benefits in terms of reduced device size in TR |
| Intel | Y |  |
| vivo | Partially Yes | We agree to capture such the observations/benefits, but we think the antenna loss due to reduced size should be able to quantify to at least a range of values. |
| Samsung | Y |  |
| Xiaomi | Y | We think this is one important factor. And the TR should include some analysis. And at this stage, Analysis on quantifying the benefit should not be precluded |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y | When reduced device size is mentioned in TR, tradeoff with other effect on important KPI, e.g. coverage, power consumption, should also be highlighted. |
| Huawei, HiSilicon | Y |  |

## 6.2 Evaluation methodology for UE power saving

Regarding Question 6, responses generally agree that the power consumption model, scaling factors, and simulations assumptions from TR. 38.840 (section 8) can be reused. However, suitable parameter values (e.g., number of antennas, UE BW, modulation order, MIMO configurations) should be considered based on RedCap UE capabilities.

**Proposal 11: Reuse the power consumption models and scaling factors for FR1 and FR2 provided in TR 38.840 (sections 8.1, 8.2, 8.3).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | With the modifications of the suitable parameter values mentioned above considering the use cases and requirements of the reduced capability NR devices, the evaluation methodology for UE power saving from TR 38.840 can be reused. |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | OK with modification (“As appropriate, …”) | We need to be careful to stay within the scope of the SID objective for RAN1.  After RAN2 is done with these power savings objectives, perhaps we can estimate the battery life of the delay tolerant use cases (nice to have, not must have). |
| SONY | Y |  |
| InterDigital | Y |  |
| Spreadtrum | Y | TR 38.840 can be reused and some modifications (additional definitions) are needed, include: a).Power consumption scaling model for UE processing capability/timeline relaxation. b). Power consumption scaling model for PDCCH monitoring capability relaxation. c). Power consumption scaling model for modulation order restriction. |
| DOCOMO | Y |  |
| Intel | N | Power consumption models can be reused, however scaling factors that are suitable for RedCap devices may need further discussion.  For instance, for FR1, only 2Rx and 4Rx have been considered in determining the scaling factors for antenna scaling in the DL. However, we need to consider 1Rx cases for at least certain FR1 bands (cf. Proposal 22). Further, such changes could also impact the factors related to some of the other reception procedures.  Therefore, we suggest to remove “and scaling factors” from Proposal 11. |
| vivo | Partially Y | We agree to reuse the existing model as much as possible, but we think still the power model should be refined or further developed at least for the following cases   * Power comsumption scaling model for reduced BW in FR2 and further refinement (esp, the sleep model) for FR1 with BW=10/20MHz * Power consumption scaling model for UE processing capability relaxation * Further refinement of power consumpion scaling model for PDCCH monitroing capability relaxaition, i.e. #BD, #CCE * Power consumption scaling model for peak data rate restrction   In addition, in power saving SI we only consider the relative power saving gain but did not quantified the UE battery life, but in RedCap SI we have the clear battery life target therefore a way to quantify it should be developed. |
| Samsung | Partially Y | It’s not necessary to reuse everything from TR38.840 (section 8). There is no 8.3 in TR38.840..  For 8.1.1 and 8.1.2, the configuration parameters can be reused, but with updates on values to address the baseline configuration of REDCAP use cases.  For 8.1.3, only need to revisit scaling rule related to PDCCH monitoring reduction. Modification for existing scaling rule of blind decoding may be needed to provide more precise model based on the new baseline configuration. In addition, new scaling rule is needed to evaluate different UE operation from R16 PS, for example, relaxation on PDCCH processing over time duration that is larger than CORESET duration, and CORESET symbol can be larger than 2.  8.1.4 can be omitted, as no need to consider idle mode or DRX operation. No need to evaluate performance for schemes studied by RAN2, e.g. eDRX, RRM relaxation.  For 8.2, only partial of 8.2 are useful. Numerical simulation or analysis on power saving gain and latency for a single UE can be reused. No need for SLS as we focus on signal connectivity in R17. No need to reuse assumption about DRX configuration. |
| Xiaomi | Y |  |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y | We should also consider if UE battery life evaluation methodology needs to be developed. |
| Huawei, HiSilicon | Yes | Some modifications may be needed. First, since the scaling for BW is defined for relatively large BW, when it comes to the case that BW is smaller than 20MHz, the value may not be so precise. Second, the traffic model should fit for REDCAP, while it should not be too complicated. |

**Proposal 12: The reference UE in the power saving evaluation is a RedCap UE defined by e.g. maximum UE channel bandwidth, number of Tx/Rx antennas, modulation order, PDCCH monitoring parameters and MIMO configuration. Values are FFS.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | As it seems that the evaluation of the power saving should go in parallel with that of the complexity reduction features, we may have to assume a few candidate RedCap UEs with different combinations of {e.g. maximum UE channel bandwidth, number of Tx/Rx antennas, modulation order, etc.}. To simplify things, two typical use cases (e.g., IWS and wearables, or low-end and high-end wearables) are proposed to represent the candidate RedCap UEs for evaluations. |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | OK if “modulation order” is removed from list | SID already says it is a redcap UE. The e.g. list should only include examples of things that may be different for a RedCap UE than a normal UE, so cannot include “modulation order”. |
| SONY | Y | For section 8 of the TR (“UE power saving and battery life enhancement”), the reference UE should be a RedCap UE (as per this proposal).  For the 7.x.4 sections (“analysis of performance impacts”), when there is an impact on power consumption, the reference UE should be the one in Proposal 9. |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| DOCOMO | Y |  |
| Intel | Y | For ease in drawing conclusions, prefer to define a single reference UE, perhaps per frequency range. |
| vivo | Partially Y | we agree the parameters list above should be considered, in addition, the following should be defined  -UE processing capability  -same-slot/cross-slot scheduling |
| Samsung | Y |  |
| Xiaomi | Partially Y | We are OK to define reference Redcap UE. But we think more than one typical candidate Redcap UE types should be defined considering different e.g., UE bandwidth, Tx/Rx configuration and different requirement. |
| TCL | Y | Maximum modulation order should be considered (e.g. 64QAM or 256QAM) |
| China Telecom | Y |  |
| Sequans | Y |  |
| Huawei, HiSilicon | Partially Yes | We think a UE capable of Rel-16 power saving techniques should somehow be as a basis. Thus e.g. per BWP configurable MIMO layers, cross-slot scheduling ect can be considered as well. |

A few responses note that the according to the SID, the RAN1 focus for the UE power saving features should be relaxed PDCCH monitoring (number of BD and CCE limits).

**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).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y |  |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y | Yes we stay within the SID |
| SONY | Y | There may be some impacts of extended DRX that need to be considered in RAN1, but we expect RAN2 to be the lead group on this feature. |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| DOCOMO | - | We are generally fine to study any other PDCCH monitoring reduction techniques, but the relation with power saving WI should be carefully considered. |
| Intel | Y |  |
| vivo | No | We think in addition to relaxed PDCCH monitoring, the power saving gain of relaxed processing capability should also be studied. |
| Samsung | Y | This is already in the SID. There is no need to make an agreement here. |
| Xiaomi | Y |  |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y (but see comment) | If UE processing time relaxation is agreed to be studied, it will also have impact on power saving and we will have to provision for its evaluation. |
| Huawei, HiSilicon | Yes |  |

Regarding Question 7, most responses agree to reuse the traffic model from TR 38.840 with proper parameters for packet size, mean inter-arrival time. One response mentions that Extended DRX parameter may need to be adjusted. Another response notes that the traffic model for connected mode can be reused.

**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.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | Potentially with down selection from the list of traffic models. For instance, suitable traffic models can be selected per each of the target use cases. |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y |  |
| SONY | Y |  |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| DOCOMO | Y |  |
| Intel | Y |  |
| vivo | Y |  |
| Samsung | Y | The assumption for packet size can be determined based on UE peak rate capability (i.e. to refer Section 7.7), and inter-arrival time can be determined based on the data rate requirement for wearables (i.e. to refer Section 5). |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y |  |
| Huawei, HiSilicon | Yes and with additions | According to our observation, the dominated traffic types for wearables are VoIP, Instant message and Heart beat. The services including voice call and video call can be categorised into VoIP. The services including WeChat, Map, navigation, and AI assistant can be regarded as Instant message. And the application layer message from client to server to inform that the service is still alive can be called Heart beat.  The traffic model for VoIP is well defined in R1-070674, so we can reuse it as we did in Rel-16 power saving WI. For Instant message and Heart beat, the traffic characteristics can be represented by FTP model 3. But the parameters, i.e. the packet size and mean inter-arrival time should be determined based on wearable traffic.  Actually in TR38.840, only two kinds of traffic model are used, i.e. FTP model 3 and VoIP. Therefore, we suggest to make the proposal more clear:  For wearables, use FTP model 3 and VoIP to characterize the RedCap service types   * Service types including IM, VoIP, heart beat, and etc. * Proper modification of at least packet size and mean inter-arrival time for each service type is needed. Values are FFS. |

Regarding Question 8, responses generally agree to reuse traffic model from TS 22.104 for industrial wireless sensor use cases. Two responses suggest considering parameters of process monitoring use case in Table 5.2-2 from TS 22.104. One response suggests reusing the Mobile Autonomous Reporting (MAR) traffic mode in TR 45.820 with appropriate adjustment if needed.

**Proposal 15: For industrial wireless sensor use cases, use the traffic model from TS 22.104 (Table 5.2-2). For the relevant parameters such as message size and transfer interval, the values for the process monitoring use case are prioritized.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y |  |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y |  |
| SONY | N | The issue is that 22.104 table 5.2.2 provides some service requirements, not a traffic model. RAN1 need to be a bit more specific about a traffic model. E.g. the traffic model for the second row of Table 5.2.2. could be:   * *Periodic transmission of 25kbyte packet every 1 second*   There are three service requirements in table 5.2.2 of TS22.104. We don’t need to study three IWSN traffic models in the Redcap SI. Can we just pick one row of Table 5.2.2. of TS22.104 and decide on a single traffic model for RAN1 purposes? |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| DOCOMO | Y |  |
| Intel | Y | Agree with SONY that we should pick one of the rows from the three sets of requirements/models from Table 5.2-2 of TS 22.104. The “Process monitoring” use case could be considered ISWN use cases. |
| vivo | Y |  |
| Samsung | - | OK to reuse TS 22.104 (Table 5.2-2). But we may not need to prioritize the use case for processing monitoring. Asset monitoring with variable packet size can be considered as well. |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y | Tuning of the traffic model parameters should follow the clarified requirements for the use case. |
| Huawei, HiSilicon | Yes | That is 20 bytes message size with 100 ms ~ 60 s transfer interval. |

## 6.3 Evaluation methodology for coverage recovery

Regarding Question 9, most responses express support for using the IMT-2020 methodology. In addition, several responses prefer to align with the CE SI, e.g. to avoid duplication of work in the two parallel SIs.

The input to mail discussion [101-e-NR-Cov-Enh] concerning link budget template also indicates that most responses favour the IMT-2020 methodology.

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y |  |
| Ericsson | Y | It should be based on the IMT-2020 methodology but go beyond it in the aspect of studying more signals/channels/messages. |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y |  |
| SONY | Y |  |
| InterDigital | Y |  |
| DOCOMO | N | CE SI will define a link budget template in the next meeting, so if the group can wait to define the template, it may be better to align with the template defined by CE SI which will be modified based on the IMT-2020 template. |
| Intel | Y |  |
| vivo | Y |  |
| Samsung | Y | The methodology should be the same as the one used in Cov\_Enh (some changes from the IMT-2020 link budget are currently discussed in Cov\_Enh SI) |
| Xiaomi | Y |  |
| TCL | Y |  |
| Sequans | Y (provisionally) | We should follow the conclusion from CE SI |
| Huawei, HiSilicon | Not really | According to the SID, coverage recovery is to compensate for potential coverage reduction due to the device complexity reduction. For UL there may be no obvious loss. For DL, we propose the following simulations:   * For PDCCH, AL-4/8/16. * For PDSCH, typical modulation order and coding rate, such as QPSK/16QAM.   Evaluation methodology based on link-level simulation can also be simplified:   * Step 1: Obtain the required SINR for the given target data rate for NR legacy UEs. * Step 2: Obtain the required SINR for the given target data rate for NR RedCap UEs. * Step 3: Obtain the performance loss on the basis of required SINR. |

Regarding Question 10, most responses prefer to perform a complete study of all relevant DL and UL channels and/or align with the CE SI. A few responses propose that beside PDCCH/PDSCH/PUSCH/PUCCH, we should consider SSB, PRACH, message 2 PDCCH, message 2 PDSCH, message 3 PUSCH, and beam switching reliability in FR2

So far, the CE SI has not agreed on a concrete set of simulations assumptions. Based on this, two alternatives are proposed:

**Proposal 17: For coverage analysis, down select between the following options during RAN1#101e:**

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.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Option (1/2)** | **Comments** |
| LG | Y | 2 | If we have to down select b/w the two options within this e-meeting (for which we don’t have a strong preference), we prefer Option 2.  The objective of study in terms of coverage recovery of RedCap UEs is slightly different from that of CE SI. For RedCap SI, it is to evaluate the coverage degradation due to complexity reduction (e.g., reduced number of Rx antennas, reduced UE bandwidth, etc.), while for CE SI, it is to identify bottleneck channels for coverage enhancement. For RedCap SI, we expect the DL coverage to be more significantly affected by complexity reduction than UL coverage, while for CE SI, it has been observed that PUSCH and PUCCH are potential bottleneck channels based on the IMT-2020 self-evaluation.  For RedCap SI, we prefer to take all relevant DL and UL signals and channels listed in Option 2 into account as we think most of them are affected by complexity reduction. |
| Ericsson | Y | 2 |  |
| Nokia, NSB | Y | 2 | We prefer to take relevant channels into account but are not sure whether we need to consider all different messages such as Msg3, Msg4, Msg5. |
| FUTUREWEI | N |  | Suggest we wait here for Cov Enh as any agreement we make increases the chance of deviation from that item. However, it is OK to note in the complexity reduction sections if we anticipate there could be some impact to e.g. PDCCH, random access etc from bandwidth reduction. |
| SONY | Y | 2 | As per LG comment, the complexity reduction features in the Redcap SI may affect DL coverage more than UL, hence the Redcap SI might have more of a focus on DL channels than the CE SI, where the focus seems to be on UL coverage. |
| InterDigital | Y | 2 |  |
| DOCOMO | Y | 2 | As it is still unclear which channel/signal is the bottleneck due to reduced capability, all relevant DL and UL channels/signals, such as SSB and PRACH, should also be included in the link budget evaluation |
| Intel | Y | 2 | Similar view as Nokia on need to assess some of the messages individually. |
| vivo |  | 2 |  |
| Samsung | N |  | We think that we should use the link budget template that is agreed in Cov\_Enh SI. Here we should agree which channels/signals to evaluate (which may or may not be the same channels/signals studied in the Cov\_Enh SI). The focus here should be on coverage recovery and on the analysis of at least PDCCH/PDSCH as first priority, and PUCCH/PUSCH, RAR, Msg3.  Having said that, we prefer to discuss which channels/signals later after cost reduction features have some general agreement. |
| Xiaomi | Y | 2 |  |
| TCL | Y | 2 |  |
| Sequans | N |  | We don’t think we need to downselect between the two options at this meeting. |
| Huawei, HiSilicon | No |  | Same reply as to proposal 16. PDCCH and PDSCH are prioritized, more channels and signals are not mandatory unless deemed necessary. |

Regarding Question 11, there is support for alignment of quality targets and performance metrics with the CE SI, but several responses suggest that certain adaptations are necessary e.g. to BLER targets to accommodate a different SINR operating point compared to that assumed in the CE SI. Based on this it is suggested to await an agreement in the CE SI and continue the discussions on targeted data rates and BLER levels once that is available. In best case the CE SI will reach an agreement during the ongoing RAN1#101e meeting based on which this document can be updated.

Regarding Question 12, again, there is support for alignment of simulation assumptions with the CE SI and based on this its suggested to await an agreement in the CE SI, and hopefully resume this discussion later during RAN1#101e.

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | We prefer to align simulation assumptions, quality targets and performance metrics with CE SI as much as possible. Of course, some adjustment can be considered if necessary. |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y | Not clear yet we need to repeat any work or simulation here, so OK to wait |
| SONY | Y | Prefer to align simulation assumptions as much as possible. |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| DOCOMO | Y | As CE SI will define the quality targets and performance metrics in this meeting, we can await the agreement. |
| Intel | Y |  |
| vivo | Y |  |
| Samsung | Y | We want to avoid duplicate discussions here and in Cov\_Enh SI. For the coverage analysis there will be link level simulation assumptions and link budget calculation. We agree in reusing what (will be) agreed in Cov\_Enh SI, then clearly we have to do modifications regarding which channels/signals are analyzed in RedCap SI, the values of several parameters in the LLS assumptions and performance target values. |
| Xiaomi | Y | We are OK to await agreement in the simulation assumptions and performance metric. But maybe there is no need to await the agreement in the quality targets. |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y |  |
| Huawei, HiSilicon | No | Same reply as to proposal 16. We can evaluate PDCCH and PDSCH based on simplified link-level simulation first. |

Regarding Question 13, most responses prefer to focus on the “Hardware link budget”.

**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 | |  |  |  |  |

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y |  |
| Ericsson | Y | Once the link budget table is agreed the numbering can be updated.  The scenario field can be used to enter the simulated channel/signal/message. |
| Nokia, NSB | Y |  |
| FUTUREWEI | N | See answer to proposal 17. OK to agree to focus on hardware link budget (assuming that will be aligned with coverage enh SI) |
| SONY | Y |  |
| InterDigital | Y |  |
| DOCOMO | N | CE SI will define a link budget template in the next meeting, so if the group can wait to define the template, it may be better to align with the template defined by CE SI which will be modified based on the IMT-2020 template. |
| Intel | Please see comments | CE SI is still discussing whether to go with IMT-2020 or the 36.824 template and associated coverage metrics. Proposal 18 suggests we wait for CE SI on “quality targets and performance metrics”, but Proposal 19 seems to influence at least some of the modeling and coverage metrics.  Specifically, unless Proposals 19 and 20 are jointly agreed, there could be some contradiction between Proposals 18 and 19. |
| Vivo | Partially Y | Agree to use “Hardware link budget” as the metric in general, the details should be aligned with CE SI. |
| Xiaomi | Y |  |
| TCL | Y |  |
| Sequans | Y |  |
| Huawei, HiSilicon |  | Whether RedCap SI should focus on determining the “Hardware link budget” or “Maximum range” can refer to the conclusions from CE SI, which is on-going. |

Several responses would in addition like to see a maximum coupling loss (MCL) calculation added to the link budget.

**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) - (22a).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y |  |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y | Also OK to wait to agree on this later |
| SONY | Y |  |
| InterDigital | Y |  |
| DOCOMO | Y | We are fine to add. On the other hand, if the group agree to use “Hardware link budget”, there may not be remarkable difference between them, since relative performance difference across channels/signals are same between them. |
| Intel | Y |  |
| vivo | N | Agree with DOCMO that having “hardware link budget” is sufficient, no strong need to have MCL as the 2nd metric. |
| Samsung | Y | We agree to add the MCL calculation. See also comment to Proposal 18. |
| Xiaomi | Y |  |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y |  |
| Huawei, HiSilicon | No | Same reply as to proposal 16. We can evaluate PDCCH and PDSCH based on simplified link-level simulation first. |

## 6.4 Evaluation methodology for other performance impacts

Regarding Question 14, most responses agreed that the evaluation of other performance impacts (than the ones mentioned in previous sections) can focus on data rate, latency, and coexistence with legacy UEs. Some responses wanted to clarify that data rate meant peak data rate. Several responses indicated that if e.g. problems or other issues are identified, it would be good to be able to add further metrics.

**Proposal 21: The evaluation of the other performance impacts focusses on at least peak data rate, latency, and coexistence with legacy UEs. Other performance metrics are not precluded.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | In the context of complexity/cost, the data rate that is more important is the ‘peak’ data rate, and the peak data rate and latency should be evaluated per use case as they are use case specifically defined. |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | N or OK with modification | Worry about the “focusses” … maybe “may include” is better. But coexistence is another section. And not clear where the technique impacts to gNB are included. For example, if supporting 50MHz for FR2 will include some additional gNB impact to restrict the usable CORESETS, this should be included. In which section? Our previous suggestion was to have coexistence be called “compatibility and coexistence”, but open to hear where the rapporteur plans for these to be captured. |
| SONY | N | Not to forget power consumption…  We are OK with including peak data rate, latency and coexistence. However, why isn’t power consumption one of the key performance impacts? Power consumption of complexity reduction features was one of the aspects that was evaluated in the hugely well-respected TR36.888. Given that the Redcap SI clearly concerns itself with power consumption (there is a section 8 in the TR for power consumption techniques), power consumption of complexity reduction techniques should clearly be of interest.  Proposal: focus on peak data rate, latency, coexistence and power consumption. |
| InterDigital | Y |  |
| Spreadtrum | Y | Reliability also needs to be considered. |
| DOCOMO | Y |  |
| Intel | Y |  |
| vivo | Partially Y | We assume power consumption is already included as one important metric? |
| Samsung | N | “Coexistence with legacy UEs” is not a performance impact, and it has a separate section in skeleton. |
| Xiaomi | Y | E.g., PDCCH blocking |
| TCL | Y/N | Agree with Sony, power consumption is a major performance metric and should be included. Perhaps the proposal can clarify what “other performance impacts (than the ones mentioned in previous sections)” are. |
| China Telecom | Y |  |
| Sequans | Y |  |
| Huawei, HiSilicon | Partially Y | As for the coexistence with legacy UEs, it would be preferable to list the potential impacts on the coexistence with legacy UEs firstly, e.g. spectrum efficiency is also an important aspect to be evaluated. |

# 7 UE complexity reduction features

## 7.1 Introduction to UE complexity reduction features

Sections 7.2 through 7.6 discuss the high-level topics for the main UE complexity reduction features. Combinations of these features are discussed in section 7.7.

## 7.2 Reduced number of UE Rx/Tx antennas

Regarding Question 15, the responses indicate a clear preference for studying 1Rx/1Tx and 2Rx/1Tx implementations. Beyond this there is some limited interest in supporting additional aspects related to the antenna.

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y |  |
| Ericsson | Y | If it is desired to take loss in antenna efficiency into consideration, then this aspect can be further discussed when we agree on the set of simulations assumptions which include antenna gain. |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y |  |
| SONY | Y |  |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| DOCOMO | Y |  |
| Intel | Y |  |
| vivo | Partially Yes | Having these two antenna configurations is fine, but we think the antenna efficiency is important factor that should be seriously considered. During the 1st round of reply, multiple UE vendors (vivo/OPPO/Samsung/Apple/Sony) emphasized the importance of antenna efficiency issue due to size limitation for wearables |
| Samsung | Y |  |
| Xiaomi | Y |  |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | [Y] | Study both 2RX/1Tx and 1Rx/1Tx configurations, but 2RX/1Tx with higher priority. We believe that 2 RX antenna should be considered as minimum for NR RedCap devices as, in combination with 20MHz BW, it will give a good balance between the device cost and the high data rate requirements of SID use cases. |
| Huawei, HiSilicon | Yes | However, in our view, only 2Rx/1Tx is supported for data rate, spectrum efficiency, coverage and scale of economy. |

Regarding Question 16, many responses indicate a clear preference for studying 2Rx/1Tx. In addition, several responses propose to include a study of 1Rx/1Tx.

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | We tend to prefer studying both 2Rx and 1Rx for FR2. The objective of studying both would be to check the difference b/w the two in terms of cost/complexly as well as the coverage impact, which can help making a conclusion based on the comparative study. |
| Ericsson | Y | We are ok to study 1Rx, but in FR2 we believe that support for 2Rx should be possible also for small form factor implementations. |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y | OK for now to include both |
| SONY | Y | Single polarized UE antenna can be an option. SSB polarization assumption should be clarified in evaluations (e.g. vertical). |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| DOCOMO | Y |  |
| Intel | Y |  |
| vivo | Y |  |
| Samsung | - | OK to study. 2Rx/1Tx should be focused for FR 2. |
| TCL | Y |  |
| China Telecom | Y | OK for both, but we prefer support 2Rx for FR2. We think the 1Rx/1Tx configuration will greatly affect the coverage impact and limit the using scenarios of UEs, but will simplify the test procedure. |
| Sequans | N | We believe 2Rx/1Tx is enough to start with for FR2. We can later consider if 1Rx/1Tx needs to also be studied after clarification of use case assumptions for FR2. |
| Huawei, HiSilicon | No | 2Rx/1Tx only seems OK |

## 7.3 UE bandwidth reduction

Regarding Question 17, most responses support prioritizing 20 MHz UE bandwidth for FR1. A few responses are fine with considering 20 MHz UE bandwidth as the baseline, but also open to considering 10 MHz or other lower bandwidths. Several responses prefer to include both 20 MHz and 10 MHz in the study.

**Proposal 24: For FR1, down select between the following options during RAN1#101e:**

1. **Study only 20 MHz maximum UE bandwidth.**
2. **Study both 20 MHz and 10 MHz maximum UE bandwidths.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Option (1/2)** | **Comments** |
| LG | Y | 2 | Prefer Option 2, with the following modification:  2. Study both 20 MHz and ~~10~~ X MHz maximum UE bandwidths. (FFS for value X b/w 5 and 10)  We basically think maximum UE bandwidth smaller than 20 MHz is useful e.g., for IWS applications in terms of cost/complexity, extended battery lifetime, etc. As there are some concerns on supporting multiple device types, we see a need to compare pros and cons of the following two approaches in the next meetings.   * Alt.1 Support the three use cases with a single device type with the maximum UE bandwidth = 20 MHz (or higher) * Alt.2 Support the three use cases with multiple device types (e.g., one with maximum UE bandwidth = 20 MHz (or higher), another with maximum UE bandwidth = 10 or 5MHz)   For the value X, take further inputs between 5 and 10 MHz for down selection in the next meetings. |
| Ericsson | Y | 1 | We do not believe 10 MHz is a good option. The CORESET#0 configuration option with 17.28 MHz bandwidth is an important configuration as it is critically important to ensure enough PDCCH capacity in the initial BWP.  We also believe that 20 MHz maximum UE bandwidth will give RedCap the best opportunity to develop a robust, healthy ecosystem, addressing a wide array of use cases in the categories of industrial sensors, wearables, video surveillance. |
| Nokia, NSB | Y | 2 | We think 10 MHz should also be studied to see whether the additional complexity reduction is worth a restriction in deployment configuration. |
| FUTUREWEI | No need to downselect, 20MHz is minimum per SID | 1 | If below 20MHz is desired it should be proposed at RAN |
| SONY | Y | 2 | But we are open to study even lower BW (SSB BW) devices and see the benefit from having such a device, especially for IWS use cases. |
| InterDigital | Y | 2 |  |
| Spreadtrum | Y | 2 | In addition, 5MHz BW @15KHz SCS may be considered. 5MHz BW are beneficial to further low cost and low power consumption. |
| DOCOMO | N | - | At first, we would like to clarify whether the assumption of those UE BWs are applicable to overall transmissions/receptions including initial access or to those only in RRC\_CONNECTED state (i.e., some other BW size ca be assumed for initial access).  It would be enough to support maximum 20 MHz UE BW to meet the required bit rate. On the other hand, as we commented in the 1st phase, when 8 ROs are FDMed with 30kHz SCS, the total BW is larger than 20MHz for initial access. If RedCap UE supports maximum 20MHz BW (i.e., maximum initial UL BWP size), the ROs outside of initial UL BWP cannot be used and hence, UE may not be able to transmit PRACH corresponding to the best SSB.  Therefore, we propose to add larger than 20 MHz (e.g. 40 MHz) UE BW for initial access for further study, or to study the solution for the above invalid RO issue if maximum 20 MHz UE BW is assumed. |
| Intel | Y | 2 | Similar view as Nokia. |
| vivo |  | 2 | The benefit provided by 10MHz BW in terms of complexity and power reduction should be studied. |
| Samsung | Y | 2 | We think 10MHz for FR1 has similar assumption as 50MHz for FR2 for SSB reception. In addition, based on some analysis 10MHz seems enough. Therefore, we propose to include 10MHz for the study. |
| Xiaomi |  |  | 20MHz should be studied for wearable.  But higher UE bandwidth should not be precluded at this stage. |
| TCL | Y | 2 | We think that 20MHz is a robust choice but lower maximum BW, e.g. 10MHz, should be evaluated. |
| China Telecom | Y | 2 |  |
| Sequans | Y | 1 |  |
| Huawei, HiSilicon | Yes | Option 1 | We propose that nothing below 20MHz UE bandwidth should be considered for Rel-17 REDCAP UEs in FR1, from the aspects of satisfying the key date rate requirement with maximized reduction of device cost and power consumption, meanwhile being compatible with Rel-15 design of SSB and CORESET#0 to minimize specification impact and retain attractive commercial values of this type of UEs. |

Regarding Question 18, many responses suggest studying both 50 MHz and 100 MHz UE bandwidth for FR2. Other proposals with support from a few responses each include study of 50 MHz only, study of 80-100 MHz only, and study of both 40-60 MHz and 80-100 MHz. Proposals with support from one response each include study of 100 MHz only, study of the range 50-100 MHz, and study of >100 MHz.

**Proposal 25: For FR2, study both 50 MHz and 100 MHz UE bandwidths.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | Both groups (50 and 100MHz maximum UE bandwidth) should be further studied. The study should involve pros and cons in terms of cost/complexity savings b/w the two and the spec/performance impact. |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | N, ok for “at least 100” | OK for 100. If 50 is included then ~80 (or the smallest value that does not have the CORESET and initial access impacts) should also be included. So maybe 100 and [50-80] if include two values. |
| SONY | Y | We are open to study even lower BW (SSB BW) devices and see the benefit from having such a device, especially for IWS use cases. |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| DOCOMO | N | Same as Proposal 24, at first, we would like to clarify whether the assumption of those UE BWs are applicable to overall transmissions/receptions including initial access or to those only in RRC\_CONNECTED state (i.e., some other BW size ca be assumed for initial access).  It would be enough to support maximum 50/100 MHz UE BWs to meet the required bit rate. On the other hand, as we commented in the 1st phase, the UE BW which supports SSB/CORESET0 multiplexing pattern 2/3 and corresponding SIB1 PDSCH should be carefully studied for initial access considering the coexistence with Rel.15/16 UEs. For SSB/CORESET0 multiplexing pattern 2 with SSB/CORESET0 SCS are 240/120 kHz, the required UE BW is larger than 100 MHz.  Therefore, we propose to add larger than 100 MHz (e.g. 200 MHz) UE BW for initial access for further study, or to study the solution for the above SSB/CORESET0 multiplexing pattern 2/3 issue if maximum 50/100 MHz UE BWs are assumed. |
| Intel | Y |  |
| Samsung | N, Ok with change 50MHz to 40~60MHz | Support the intention of the proposal in general, but we suggest to change 50MHz to 40~60MHz. And we can decide one value based on the output of a study. |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | [Y] | We can agree to study at least these two bandwidths for FR2. But it is for FFS for us and would be open to explore in the study the performance/specification impact of other options. |
| Huawei, HiSilicon | No | Only 100MHz is studied in FR2.  In FR2, both 120kHz and 240 kHz SCS should be supported, so the maximum bandwidth of SSB bandwidth and CORESET#0 can be up to 57.6MHz and 69.12MHz. In order to reuse Rel-15 SSB bandwidth and minimize specification impact, reduced UE bandwidth should be no less than that. |

## 7.4 Half-duplex FDD operation

Regarding Question 19, many responses or propose to prioritize the HD-FDD operation type that is in LTE known as Type A. Many indicate that there is no strong motivation to study HD-FDD devices with single PLL/LO due to marginal cost saving. Almost as many responses suggest both Type A and Type B are included in the study. A few responses argue that the small cost reduction of HD-FDD cannot justify the study.

**Proposal 26: Down select between the following options during RAN1#101e:**

1. **Study only HD-FDD operation Type A.**
2. **Study both HD-FDD operation Type A and Type B.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Option (1/2)** | **Comments** |
| LG | Y | 2 | For the device type or target use case where the cost is most critical and the required peak data rate is small, HD-FDD Type B should be taken into account. |
| Ericsson | Y | 1 | We took note that many UE companies have already indicated the cost reduction achieved by reducing the number of local oscillators from two to one is marginal. Thus, we support to only focus on Type A. |
| Nokia, NSB | Y | 2 |  |
| FUTUREWEI | Y | 1 |  |
| SONY | Y | 2 | This is a study, so we should study which of Type A or Type B is preferable before jumping to conclusions. |
| InterDigital | Y | 2 |  |
| Spreadtrum | Y | 2 | Considering the switching capability of the complexity reduced UE, the definition of HD-FDD operation type may need to be reconsidered and for different scenarios (i.e. different use cases), different HD-FDD operation types may be necessary. |
| DOCOMO | Y | 2 | We can assume HD-FDD Type A as baseline, but HD-FDD can be assumed for the use case where the device cost is critical but data rate/latency are not. |
| Intel | Y | 1 | Type A should at least be prioritized; Type B can be considered if sufficiently motivated. |
| vivo |  | 1 | Prioritize type A |
| Samsung | Y | 2 | We can decide whether to support single PLL/LO based on the output of the study on complexity analysis. |
| Xiaomi | Y | 2 |  |
| TCL | Y | 2 |  |
| China Telecom | Y | 2 |  |
| Sequans | N | [1] | To avoid waste of unnecessary study time, we prefer to first discuss and clarify whether cost/complexity benefit is justifiable, considering the scheduling/latency constraints introduced. Maybe this needs to be compared with evaluated cost reductions from other techniques. If found promising and not limiting on the application of low-latency use cases, then we prefer to prioritize type A which introduces less constraint. |
| Huawei, HiSilicon | No |  | We think HD-FDD will cause low data rate, coverage reduction and high latency since the UEs with HD-FDD cannot simultaneously transmit and receive signals and require big guard overheads, e.g. two full subframes of guard period before and after the start and end of an uplink transmission in LTE, respectively. However, the rough cost reduction estimation may be less than 10% compared with FD-FDD according to TR36.888.  If there is majority support for study one of them, Type A is preferred. |

Many responses suggest the values of DL-to-UL and UL-to-DL guard periods should be determined by RAN4.

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | For the values of guard periods required for Type A and Type B, we will probably need inputs from RAN4. |
| Ericsson |  | RAN1 can probably carry out initial analysis of the potential cost/complexity reduction before deciding whether it is necessary to involve RAN4. |
| Nokia, NSB | Y |  |
| SONY | N | RAN1 can have initial numbers and RAN4 can verify. |
| InterDigital | Y |  |
| Spreadtrum | Y | The values of DL-to-UL and UL-to-DL guard periods should be determined by RAN4, but RAN1 should study the requirements of guard period, and provide suggestion values. |
| DOCOMO | Y |  |
| Intel | Y |  |
| vivo | Y |  |
| Samsung | Y |  |
| Xiaomi | Y | Suggest to change” DL-to-UL and UL-to-DL guard periods “ as “DL-to-UL and UL-to-DL switching time” |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y | We have no problem with that suggestion, given that study of HD-FDD operation is agreed (as commented in above question). |
| Huawei, HiSilicon | Yes |  |

## 7.5 Relaxed UE processing time

Regarding Question 20, most responses share the view that a more relaxed UE processing time capability in terms of N1/N2 compared to capability #1 should be studied, including impacts on latency, scheduling flexibility (e.g. cross-slot scheduling restriction), power saving, specifications (e.g. PDSCH/PUSCH TDRA tables), and dependency on PDCCH monitoring relaxation.

Some responses do not support the study, highlighting that it is unclear how much cost reduction can be attained and that the relaxation will impose a limitation on the application of low-latency use cases.

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | It somehow depends on the use case. For some use cases such as smart wearables with moderate or high peak data rate, the relaxation may not be needed or even not useful. However, for use cases such as low cost sensors not supporting latency-critical functions, operation with low clock speed can be beneficial in terms of cost and power consumption. For how much the benefit would be, we need to further study during the study item phase. |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | N | The entire bullet can be considered as a lower priority. For the techniques that we study here, they can have the same (lower) priority. We think that relaxing the cross-slot scheduling timing is the most promising technique to study.  The SID says we study “Relaxed UE processing time” but not necessarily the introduction of a new capability. So if N1 and N2 are studied, there should be NO implication that we are studying a new processing *capability.* |
| SONY | Y |  |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| DOCOMO | Y | It should be studied as included in the objective of the SID |
| Intel | Y |  |
| vivo | Agree to study but proposal should be updated | Agree it is an important aspect to be studied, but both benefit and performance impacts should be studied  Suggest to update the proposal as  **Proposal 28: Study a more relaxed UE processing time capability in terms of N1/N2 compared to capability #1, including the cost/complexity reduction and power saving benefit, and the impacts on latency and scheduling flexibility (at least qualitatively).** |
| Samsung | Y with additional comment | We think cross-slot scheduling and PDCCH monitoring relaxation can also be included. |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y | N1/N2 relaxation together with PDCCH monitoring relaxation should be also evaluated to clarify joint gain and impact. |
| Huawei, HiSilicon | No | We propose not to relax UE processing time compared with capability #1 for REDCAP UEs. Because relaxing processing time imposes limitation on the application of low latency use cases. Moreover, the cost saving arising from relaxed processing time seems trivial compared to other potential techniques. However as SID, it is probably OK to have  **Proposal 28: Study a more relaxed UE processing time capability in terms of N1/N2 compared to capability #1, including the impacts on cost saving, latency and scheduling flexibility (at least qualitatively).** |

Regarding Question 21, many responses express views to study different aspects of other relaxed UE processing time. Some of them, including cross-slot scheduling, HARQ RTT relaxation, and PDCCH processing time can potentially be interpreted as being part of the proposed study on relaxed N1/N2.

Regarding CSI computation time, several responses proposed that it can be studied. It was however mentioned that there is a dependency on potential reduction of the number of UE antennas and MIMO layers.

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y |  |
| Ericsson | Y | The relaxed CSI computation time can be studied but with lower priority compared to N1/N2 relaxation. |
| Nokia, NSB | Y | Agree with Ericsson that this should have lower priority. |
| FUTUREWEI | Y | OK to include with cross-slot scheduling, with entire objective as lower priority. See above answer. |
| SONY | Y | OK to study this, but it is not a priority for us. |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| DOCOMO | Y |  |
| Intel | Y |  |
| vivo | Y | OK to study |
| Samsung | Y | With low priority and wait until the potential reduction on Rx. |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y | We are fine with this approach.  In addition, we believe that scope of study on relaxed UE processing time should include coherent processing times in the UE. |
| Huawei, HiSilicon | No | The cost saving arising from relaxed CSI computation time seems trivial compared to other potential techniques. |

## 7.6 Relaxed UE processing capability

Regarding Question 22, most responses suggest that relaxation on peak data rate via the following techniques may be beneficial and should be studied.

* Restriction on the maximum TBS size
* Maximum modulation order restriction
* Reducing the maximum number of MIMO layers

However, a few responses note that if it is desired to address all use cases using a single RedCap UE type, then the potential for cost/complexity reduction may be limited. Furthermore, a few responses point out that the studies of reduced BW and reduced number of antennas should be prioritized before considering the peak rate relaxation that would not necessarily contribute significantly to additional cost/complexity reduction.

A few responses further suggest that it may be beneficial to relax the maximum number of supported HARQ processes, while one response notes that there are no soft buffer requirements in NR, and hence it is not clear whether it is necessary or beneficial to reduce the number of HARQ processes. Furthermore, it is pointed out that a larger number of HARQ processes may be necessary to recover throughput losses in TDD or HD-FDD operations.

A few responses also note that CA support could may be beneficial for meeting the peak data rate requirements, while one response argues that CA should not be supported.

**Proposal 30:** **Study peak data rate relaxation and focus on:**

* **Restriction on the maximum TBS size**
* **Maximum modulation order restriction**
* **Reducing the maximum number of MIMO layers**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG |  | For the support of CA mentioned above, not clear what it means if the CA is not in the list to focus on. We don’t see a clear needs for supporting CA for RedCap UEs, but see a benefit not supporting the CA in terms of cost/complexity. If the absence in the list means they are not supported, then the proposal is agreeable, but otherwise, we need to add a bullet for “Restriction on the support of CA”. |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | N since “peak data rate” or “maximum TBS” are mentioned | SID is not defined, not a “blank check”. If there is any controversy, the item should be deprioritized and scope discussed in RAN.  We are only OK to include reduction in MIMO layers, and, after seeing the responses, a very specific item to consider making 64 QAM optional on the UL. (we should never say that a device cannot optionally support a feature). We are NOT ok to including the generic “peak data rate relaxation” or the specific “restriction to maximum TBS size”. We are NOT ok for any other techniques.  BW reduction will also reduce processing, and should be progressed before any study here.  These three items should not be listed under “peak data rate”: MIMO and modulation restriction may also reduce peak data rate but that is not the main reason to consider those processing relaxations. |
| SONY | Y | Also studying HARQ simplifications in general would still be preferable. |
| InterDigital | Y |  |
| Spreadtrum | Y | Reducing the maximum number of HARQ process may be considered for cost reduction purpose.  On the other hand, as well as modulation order and MIMO layer, the number of REs (RB allocation of PDSCH/PUSCH) can be defined as a separate capability. |
| DOCOMO | Y | It is noted that the proposal just says “Study”. It does not mean that the features listed above are supported and we can discuss further on the feasibility on each feature. In the sense, we are fine to study further all the three features listed above. Moreover, we also prefer to study the feasibility of the reduction of the number of HARQ processes. |
| Intel | Y | To LGE’s comment, our understanding is that we may not need to focus on CA here, with the understanding that CA could be considered for optional support for more demanding use cases with high peak rate requirements. Such an approach should be fine for the current analysis since CA is anyway an optional feature for R15 NR UEs.  On number of HARQ processes, with the decoupling of Rx side softbuffer requirements and # of HARQ processes, the benefits from reducing # of HARQ processes do not seem to be substantial. |
| vivo | The proposal is not a complete list | We think the reduced number of HARQ process is missing |
| Samsung | N | First of all, there is no peak data rate target, and it is not one solution for cost reduction.  Secondly, there is no need to study “restriction on max TBS”. Combining with BW and Rx reduction, the gain is not expected to be large. |
| TCL | Y |  |
| China Telecom | Y | Better to add HARQ process. |
| Sequans | [Y] | We think it is may also prove necessary to consider additional restrictions in the study, e.g. of maximum number of CC and CC configuration (intra vs. inter band). So, maybe proposal 30 could be slightly modified for more flexibility: “Study … and focus **at least** on …” |
| Huawei, HiSilicon | Yes | * MIMO layers: 2 layers for DL, 1 layer for UL * Modulation: 64QAM for UL and DL * BW: 20MHz * TBS: caculated according to the above factors |

Regarding Question 23, several responses indicate that processing capability relaxation based on CSI measurement/feedback/reporting relaxation for FR1/FR2 and beam management simplification for FR2 should be studied.

However, many responses also think that further UE processing capability relaxations are not needed or that such studies should have low priority.

**Proposal 31: Study of CSI measurement/feedback/reporting relaxation for FR1/FR2 and beam management simplification for FR2 is not prioritized.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | We have a view that those techniques mentioned above are somehow optimizations on top of the major factors in terms of cost/complexity and whether those optimizations are needed or not is somehow dependent upon the target use cases and whether they are supported via a single device type or multiple device types. We are open to study them but, also agree they are not prioritized for the moment. |
| Ericsson | N | We would like to at least study beam management simplification for FR2 (but with lower priority than peak rate relaxation). |
| Nokia, NSB | N |  |
| FUTUREWEI | TBD | Should see the outcome of the MIMO WI work on FR2. As above, nothing has been agreed for this objective and the entire objective can be deprioritized. |
| SONY | N | We see no point in excluding this at least for FR2. |
| InterDigital | N |  |
| DOCOMO | Y | We are open to study but with low priority |
| Intel | N | We believe there is considerable room for these features towards simplification and thus, should not be deprioritized at this stage.  In addition to CSI feedback and beam management related simplifications, we think the following should also be studied:   * Restricting UL waveform to DFT-S-OFDM only * Simplifications to LDPC for PDSCH/PUSCH, e.g., use of BG2 only for RedCap NR UEs can help significantly with decoder complexity * Other baseband simplifications, like simultaneous reception requirements, rate-matching requirements, etc. |
| vivo |  | Can be considered if time permits. |
| Samsung | Y | Rel-17 MIMO will have some enhancements including beam management. Therefore, it is not preferred to study in RedCap SI. |
| TCL | Y | Ok, but low priority |
| Sequans | Y |  |
| Huawei, HiSilicon | Yes |  |

## 7.7 Combinations of UE complexity reduction features

Regarding Question 24, several responses express a preference to postpone this discussion to e.g. first gain an understanding of the individual cost reducing techniques. Based on this it is suggested to come back to this topic at the next meeting. (See also the related discussion in section 6.1 in this document.)

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | Agree on the introductory remarks. |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y | Like proposal 6: This can be down-prioritized until after we have progress on the main individual techniques further. |
| SONY | Y | This “complexity combination” activity didn’t provide much insight in 36.888 and consumed time. |
| InterDigital | Y |  |
| Spreadtrum | Y | Same comments as to proposal 6: “For simplicity, we need to decide how many features need to be studied first and then consider the combination.” |
| DOCOMO | Y |  |
| Intel | Y |  |
| vivo | Y | This should be low priority for the SI |
| Samsung | Y | It is too early to discuss this. |
| Xiaomi | Y |  |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y |  |
| Huawei, HiSilicon | Yes |  |

# 8 UE power saving and battery lifetime enhancement

## 8.1 Reduced PDCCH monitoring

Regarding Question 25, several responses discuss various techniques for reducing the number of blind decodes and CCEs including reduction of: 1) the number of different DCI sizes (i.e., DCI size budget), 2) number of ALs and PDCCH candidates, 3) number of search spaces and CORESETs monitored by UE, and 4) defining BD/CCE limits per extended span gap (e.g., multi-slot). A few responses request a clarification of whether limiting the BD and CCE by configuration is not enough.

Regarding Question 26, based on the responses from the responses, the impact of BD and CCE limits reduction at least on the PDCCH blocking probability should be studied. In addition, the impact on the latency (for latency-sensitive use cases, e.g., safety-related sensors) and scheduling flexibility can be studied.

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | For adoption of the techniques listed above, the performance impact (e.g., increase in the PDCCH blocking probability) should be taken into consideration. |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y |  |
| InterDigital | Y |  |
| Spreadtrum | Y | For now, it is unclear how much power saving gain we can get by reducing the number of BD and CCE, we need to consider those impacts on the basis of power saving gain. |
| DOCOMO | Y |  |
| Intel | Y |  |
| vivo | Agree to study but the proposal should be updated | Agree to study but both benefit and performance impacts should be studied.  Suggest to update the proposal as following  **Proposal 33: Study the cost/complexity and power saving benefit of relaxing BD and CCE limits and the performance impact including PDCCH blocking probability (quantitatively) ~~and resulting impacts on latency~~ and scheduling flexibility (at least qualitatively).** |
| Samsung | Y | We see no need to make this agreement before starting the work although we don’t disagree.  This should be part of the evaluation methodology for UE power saving based on reduction on PDCCH monitoring. |
| Xiaomi | Y |  |
| TCL | Y |  |
| China Telecom | Y |  |
| Sequans | Y | We are also open to consider other trade-offs for study, if any is identified later on. |
| Huawei, HiSilicon | Yes | Since the fewer number of CCEs would bring scheduling constrains and little benefit on power saving, we suggest to focus on the techniques of reducing the max. number of DCI sizes. |

Regarding Question 27, there does not seem to be consensus that any other techniques for relaxed PDCCH monitoring than smaller numbers of blind decodes and CCE limits should be studied for UE power saving.

**Proposal 34: Study of other techniques for relaxed PDCCH monitoring than smaller numbers of blind decodes and CCE limits for UE power saving is not prioritized.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | N | We prefer not to prioritize among techniques we will study during the SI phase. Having a discussion on prioritization at the end of the SI, with the study results, is preferred. Furthermore, the scope of the “other techniques for relaxed PDCCH monitoring than smaller numbers of blind decodes and CCE limits” are not clear enough which may be controversial after prioritization anyway. |
| Ericsson | Y | In our view, the focus should be on studying BD and CCE limits reduction, which is also mentioned in the SID. In order to study other PDCCH relaxation techniques, there need to be a clear justification and benefit. Moreover, given the limited time, it may not be feasible to study various potential techniques for PDCCH relaxation. |
| Nokia, NSB | Y | We should first focus only on BD and CCE limits reduction per SID. |
| FUTUREWEI | Y | Not only not prioritized, they are not in the SID. Can update SID later if want to include more. |
| InterDigital | Y |  |
| Spreadtrum | N | The number of different DCI sizes (i.e., DCI size budget) should be also considered. |
| DOCOMO | Y |  |
| Intel | N | As captured in Proposal 33, the impact on PDCCH blocking due to reduction in BD/CCE limits should be studied. Consequently, at least techniques that help justify feasibility of such relaxed requirements by mitigating the adverse impact to overall system efficiency should not be precluded at this stage.  Additionally, we support the suggestion from Spreadtrum for the consideration of reduced number of DCI format sizes. |
| vivo | N | In our view, the following should be studied for reduced PDCCH monitoring   * Reduced number of configurable CORESET per BWP. * Reduced number of configurable search space per BWP. * Reduced number of CCE per slot * Reduced number of BD per slot * Reduced DCI size budget. * Dynamic adaptation of PDCCH monitoring |
| Samsung | Y | The SID objective is clearly the first priority. We are open to consider other techniques if time allows. |
| Xiaomi | N | In our view, some other solutions such as multi-TB scheduling ,compact DCI should not be precluded |
| TCL | Y | We think that a potential reduction of the limits on the number of CORESETs, search spaces and DCI sizes should be part of the study. All other techniques to reduce PDCCH monitoring are part of the power saving WI and only theirs applicability to redcap devices should be studied. |
| China Telecom | Y |  |
| Sequans | Y |  |
| Huawei, HiSilicon | Partially Yes | The assumption should be that techniques available from Rel-16 power saving WI are based as much as possible, in order to maximize the output of previous work only with necessary adaptation. For other techniques in addition to Rel-16 and that provided in Rel-17 RedCap SID, can be viewed as not prioritized. |

# 9 Other comments

Comments that do not fit in any of the previous sections of this document can be provided in this section. Note that the TR skeleton is discussed in a separate email discussion [101-e-NR-RedCap-Skeleton].

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG | We have three main use cases which need to be supported but are quite diverse in terms of required peak data rates, battery life, mobility, etc. During the study item phase, in our view, the discussion on UE maximum bandwidth of the reduced capability NR devices is urgent and should be studied based on the required peak data rate per each use case. Based on that or in parallel with the discussion on that, whether the three main use cases should be supported via a single device type or multiple device types can be discussed based on the pros and cons in terms of cost/complexity, spec impact, NR coexistence, and so on.  We tend to think the need for more device types will probably be getting bigger along with increasing market based on NR system, so our standardization framework for redcap devices should somehow minimize the shocks and stresses of future introduction of more devices types optimized for some popular use cases. |
| Ericsson | Regarding the number of RedCap UE types, we hope that the most basic RedCap UE type will be able to address most of the targeted use cases. However, we are open to consider the possibility to be able to add optional UE capabilities (e.g. MIMO or CA) on top of this basic RedCap UE type in order to address the more advanced use cases (e.g. high-end wearables). It is probably too early to try to reach conclusions on the definitions of these UE types/capabilities already at this very first meeting in the study item. |
| FUTUREWEI | The rapporteur should be commended for the large amount of material covered in this discussion. However we need to take great care to be able to progress the most important aspects as time is limited, especially during the COVID-19 pandemic where meetings are less efficient. Care should be taken not to exceed the scope of what we have in the SID, and “nice to have” aspects should be deferred as we progress the big ticket aspects. We do not want to see something akin to an MTC study in rel-11 (rel-17 here) and then the work finally completing in Rel-13 (rel-19 here). The amount of coverage compensation will be less as we are not LPWA, but we have FR2, size considerations, power considerations, three use cases, etc etc.  If needed, we can ask RAN to clarify the scope or objectives. |
| Intel | Views copied from previous round:  A single type of RedCap NR UEs should be pursued. Further separation via support of certain optional UE features should be considered to realize a scalable framework. Considering this is the first release for RedCap NR UEs, care needs to be taken to ensure that we design a future-proof and scalable framework that can adapt further based on particular use cases identified in the future.  In terms of the capability framework, the current capability reporting framework in NR should be maximally reused. Also, related to reference UE model and also when considering relaxations to UE processing capabilities, focus on features that are mandatory in Rel-15 and Rel-16. The only exception would be for any optional feature(s) that can be beneficial if optionally supported by some RedCap use cases (e.g., DL CA, DL SPS, UL CG PUSCH, etc.), and those that may need to be adapted for support by RedCap NR UEs. |
| vivo | There are battery life requirement for industrial sensors and wearables, it is not clear what the plan for the battery life evaluation is. We understand this is not an easy task but as it is clearly stated in the SID, it seems necessary to have some study on it. |
| Xiaomi | It is too early to confine the types of UE to only one since the requirement gap for the three use cases is obvious. Even for wearable, for instance the smart watch, low-end and high-end seems to be different as well. |
| Sequans | Cat-0 was never deployed. This SI should avoid leading to similar outcome, i.e. RedCap variant never deployed. The SI should define meaningful outcomes for the market even if it takes more time. |

# 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)

[3] [R1-2003281](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003281.zip), “Analysis of complexity reduction features for RedCap UEs”, Futurewei

[4] [R1-2003282](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003282.zip), “Coverage recovery for RedCap”, Futurewei

[5] [R1-2003283](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003283.zip), “Framework for RedCap UEs”, Futurewei

[6] [R1-2003289](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003289.zip), “Potential UE complexity reduction features for Redcap”, Ericsson

[7] [R1-2003290](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003290.zip), “Reduced PDCCH monitoring for Redcap”, Ericsson

[8] [R1-2003291](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003291.zip), “Functionality for coverage recovery for Redcap”, Ericsson

[9] [R1-2003292](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003292.zip), “Higher-layer aspects for Redcap”, Ericsson

[10] [R1-2003301](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003301.zip), “Potential UE complexity reduction features”, Huawei, HiSilicon

[11] [R1-2003302](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003302.zip), “Power saving for reduced capability devices”, Huawei, HiSilicon

[12] [R1-2003303](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003303.zip), “Functionality for coverage recovery”, Huawei, HiSilicon

[13] [R1-2003307](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003307.zip), “Potential UE complexity reduction features”, China Unicom

[14] [R1-2003344](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003344.zip), “Reduced Capability UE Complexity Reduction Features”, Sierra Wireless, S.A.

[15] [R1-2003431](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003431.zip), “Capability and complexity reduction for Reduced Capability NR devices”, vivo, Guangdong Genius

[16] [R1-2003432](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003432.zip), “Reduced PDCCH monitoring for Reduced Capability NR devices”, vivo, Guangdong Genius

[17] [R1-2003433](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003433.zip), “Discussion on functionality for coverage recovery”, vivo, Guangdong Genius

[18] [R1-2003434](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003434.zip), “RRM relaxation for Reduced Capability NR devices”, vivo, Guangdong Genius

[19] [R1-2003546](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003546.zip), “Power savings for RedCap UEs”, Futurewei

[20] [R1-2003558](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003558.zip), “Functionality for Coverage Recovery”, Panasonic Corporation

[21] [R1-2003644](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003644.zip), “Discussion on potential UE complexity reduction features”, CATT

[22] [R1-2003645](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003645.zip), “Discussion on PDCCH monitoring reduction”, CATT

[23] [R1-2003646](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003646.zip), “Coverage recovery for reduced capability NR devices”, CATT

[24] [R1-2003647](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003647.zip), “Identification and access restriction for reduced capability NR devices”, CATT

[25] [R1-2003687](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003687.zip), “On complexity reduction features for NR RedCap UEs”, MediaTek Inc.

[26] [R1-2003688](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003688.zip), “Discussion on reduced PDCCH monitoring for NR RedCap UEs”, MediaTek Inc.

[27] [R1-2003689](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003689.zip), “Discussion on coverage recovery for NR RedCap UEs”, MediaTek Inc.

[28] [R1-2003711](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003711.zip), “View on reduced PDCCH monitoring for NR devices”, NEC

[29] [R1-2003770](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003770.zip), “On potential UE complexity reduction features”, Intel Corporation

[30] [R1-2003771](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003771.zip), “On PDCCH monitoring simplifications for RedCap NR Ues”, Intel Corporation

[31] [R1-2003772](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003772.zip), “On coverage recovery for RedCap NR UEs”, Intel Corporation

[32] [R1-2003801](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003801.zip), “Discussion on potential UE complexity reduction features”, ZTE

[33] [R1-2003802](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003802.zip), “Considerations on reduced PDCCH monitoring”, ZTE

[34] [R1-2003803](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003803.zip), “Discussion on functionality for coverage recovery”, ZTE

[35] [R1-2003804](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003804.zip), “Discussion on UE categories for reduced capability NR devices”, ZTE

[36] [R1-2003828](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003828.zip), “On UE complexity reduction features”, Lenovo, Motorola Mobility

[37] [R1-2003829](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003829.zip), “On coverage enhancement for RedCap”, Lenovo, Motorola Mobility

[38] [R1-2003910](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003910.zip), “UE complexity reduction”, Samsung

[39] [R1-2003911](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003911.zip), “Reduced PDCCH monitoring”, Samsung

[40] [R1-2003912](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003912.zip), “Coverage recovery for low capability device”, Samsung

[41] [R1-2003913](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003913.zip), “Considerations on access barring and UE capability”, Samsung

[42] [R1-2003922](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003922.zip), “View on reduced capability NR devices”, NEC

[43] [R1-2003934](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003934.zip), “UE complexity reduction features”, Nokia, Nokia Shanghai Bell

[44] [R1-2003935](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003935.zip), “Reduced PDCCH monitoring”, Nokia, Nokia Shanghai Bell

[45] [R1-2003936](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003936.zip), “Functionality for coverage recovery”, Nokia, Nokia Shanghai Bell

[46] [R1-2003966](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003966.zip), “Discussion on UE complexity reduction”, CMCC

[47] [R1-2003967](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003967.zip), “Discussion on PDCCH monitoring reduction for Reduced Capability NR Devices”, CMCC

[48] [R1-2003968](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003968.zip), “Consideration on coverage recovery for Reduced Capability NR Devices”, CMCC

[49] [R1-2003969](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003969.zip), “Discussion on framework of Reduced Capability NR Devices”, CMCC

[50] [R1-2003995](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003995.zip), “Discussion on potential UE complexity reduction features”, Spreadtrum Communications

[51] [R1-2003996](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003996.zip), “Discussion on reduced PDCCH monitoring”, Spreadtrum Communications

[52] [R1-2003997](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003997.zip), “Consideration on power saving for reduced capability NR devices”, Spreadtrum Communications

[53] [R1-2003998](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003998.zip), “Discussion on functionality for coverage recovery”, Spreadtrum Communications

[54] [R1-2004021](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004021.zip), “Discussion on potential UE complexity reduction features”, LG Electronics

[55] [R1-2004022](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004022.zip), “Discussion on PDCCH monitoring for reduced capability NR devices”, LG Electronics

[56] [R1-2004023](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004023.zip), “Discussion on the coverage recovery of reduced capability NR devices”, LG Electronics

[57] [R1-2004024](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004024.zip), “Consideration on the framework to support reduced capability NR devices”, LG Electronics

[58] [R1-2004104](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004104.zip), “Discussion on UE complexity reduction”, OPPO

[59] [R1-2004105](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004105.zip), “Discussion on reduced monitoring for PDCCH”, OPPO

[60] [R1-2004106](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004106.zip), “Discussion on functionality for coverage recovery”, OPPO

[61] [R1-2004107](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004107.zip), “Consideration on reduced UE capability”, OPPO

[62] [R1-2004172](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004172.zip), “Potential UE complexity reduction features”, TCL Communication Ltd.

[63] [R1-2004173](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004173.zip), “Reduced PDCCH monitoring”, TCL Communication Ltd.

[64] [R1-2004176](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004176.zip), “Discussion on RedCap”, Sequans Communications

[65] [R1-2004193](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004193.zip), “On potential UE complexity reduction features for NR devices”, Sony

[66] [R1-2004194](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004194.zip), “Battery lifetime enhancement for reduced capability NR devices through reduction of PDCCH monitoring”, Sony

[67] [R1-2004195](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004195.zip), “Coverage recovery techniques for reduced capability NR devices”, Sony

[68] [R1-2004251](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004251.zip), “Standard Aspects of UE complexity Reduction Features”, Apple

[69] [R1-2004252](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004252.zip), “PDCCH Monitoring for Reduced Capability Devices”, Apple

[70] [R1-2004253](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004253.zip), “Coverage recovery for reduced capability NR devices”, Apple

[71] [R1-2004270](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004270.zip), “On the effect of reducing the number of UE Rx antennas on DL capacity”, Orange

[72] [R1-2004302](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004302.zip), “Considerations on reducing PDCCH monitoring”, Fujitsu

[73] [R1-2004306](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004306.zip), “Discussion on potential UE complexity reduction features”, Panasonic Corporation

[74] [R1-2004314](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004314.zip), “Complexity reduction features for reduced capability NR devices”, InterDigital

[75] [R1-2004315](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004315.zip), “Reduced PDCCH monitoring for reduced capability NR devices”, InterDigital

[76] [R1-2004317](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004317.zip), “Coverage enhancement for reduced capability NR devices”, InterDigital

[77] [R1-2004318](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004318.zip), “Orthogonal ON/OFF keying for wake-up signal design”, InterDigital

[78] [R1-2004335](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004335.zip), “Discussion on Potential UE complexity reduction features”, Sharp

[79] [R1-2004336](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004336.zip), “Reduced PDCCH monitoring for reduced capability UEs”, Sharp

[80] [R1-2004337](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004337.zip), “Coverage recovery for reduced capability UEs”, Sharp

[81] [R1-2004373](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004373.zip), “PDCCH monitoring at reduced capability UEs”, Motorola Mobility, Lenovo

[82] [R1-2004374](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004374.zip), “Narrowband operation at reduced capability UEs”, Motorola Mobility, Lenovo

[83] [R1-2004421](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004421.zip), “Potential UE complexity reduction features for RedCap”, NTT DOCOMO, INC

[84] [R1-2004422](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004422.zip), “Reduced PDCCH monitoring for RedCap”, NTT DOCOMO, INC

[85] [R1-2004423](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004423.zip), “Functionality for coverage recovery for RedCap”, NTT DOCOMO, INC

[86] [R1-2004493](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004493.zip), “Considerations for Complexity Reduction of RedCap Devices”, Qualcomm Incorporated

[87] [R1-2004494](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004494.zip), “Considerations for PDCCH Monitoring Reduction and Power Saving of RedCap Devices”, Qualcomm Incorporated

[88] [R1-2004495](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004495.zip), “Considerations for Coverage Recovery of RedCap Devices”, Qualcomm Incorporated

[89] [R1-2004496](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004496.zip), “Considerations for Standardization Framework and Design Principles of RedCap Devices”, Qualcomm Incorporated

[90] [R1-2004506](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004506.zip), “Initial discussion on the complexity reduction for reduced capability device”, Xiaomi Technology

[91] [R1-2004514](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004514.zip), “Initial discussion on the reduced PDCCH monitoring for reduced capability devices”, Xiaomi Technology

[92] [R1-2004532](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004532.zip), “Initial discussion on coverage recovery for reduced capability”, Xiaomi Technology

[93] [R1-2004535](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004535.zip), “On the framework and principles of Reduced Capability NR Devices”, Xiaomi Technology

[94] [R1-2004536](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004536.zip), “Discussion on potential UE complexity reduction features”, Asia Pacific Telecom co. Ltd

[95] [R1-2004541](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004541.zip), “Discussion on reducing PDCCH monitoring for RedCap UEs”, PANASONIC

[96] [R1-2004557](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004557.zip), “UE Complexity Reduction for Reduced Capability NR Devices”, Potevio

[97] [R1-2004595](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004595.zip), “On potential UE complexity reduction features”, Convida Wireless

[98] [R1-2004596](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004596.zip), “On coverage recovery for reduced capability UEs”, Convida Wireless

[99] [R1-2004612](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004612.zip), “Other aspects for reduced capability devices”, Huawei, HiSilicon