3GPP TSG-RAN WG1 Meeting #103-e Tdoc R1-20xxxxx

e-Meeting, October 26th – November 13th, 2020

**Agenda Item: 8.6.1**

**Title: FL summary #6 for Potential UE complexity reduction features for RedCap**

**Source: Moderator (Ericsson)**

**Document for: Discussion, Decision**

# 1 Introduction

Contributions [1] – [28] submitted to RAN1#103e AI 8.6.1 plus relevant parts from a few contributions [29] – [34] that were submitted to other agenda items under AI 8.6, as well as initial evaluation results in [35], were summarized in FL summary #1 (FLS1) in [R1-2008869](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2008869.zip).

This document captures the following RAN1#103e RedCap email discussion.

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| [103-e-NR-RedCap-02] Email discussion for potential UE complexity reduction features – Johan (Ericsson)   * 1st check point: 10/29 * 2nd check point: 11/4 * 3rd check point: 11/10 * Last check point 11/12 |

The previous round of this email discussion is documented in FL summary #5 (FLS5) in R1-2009651 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/R1-2009651.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009651.zip)).

In this round of the email discussion, please provide input on the following:

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| * By Thursday 12th November 23:00 UTC:   + FL proposals for endorsement tagged ‘FL3: Phase 1:’   + FL proposals for endorsement tagged ‘FL3: Phase 2:’   + FL proposals for endorsement tagged ‘FL3: Phase 3:’ |

In ALL file names, please use hyphen characters (not underline characters) and include ‘v’ in front of the version numbers.

Follow the naming convention in this example:

* *RedCapComplexityFLS6-v000.docx*
* *RedCapComplexityFLS6-v001-CompanyA.docx*
* *RedCapComplexityFLS6-v002-CompanyA-CompanyB.docx*
* *RedCapComplexityFLS6-v003-CompanyB-CompanyC.docx*

If needed, you may “lock” a spreadsheet file for 30 minutes by creating a checkout file, as in this example:

* Assume CompanyC wants to update *RedCapComplexityFLS6-v002-CompanyA-CompanyB.docx*.
* CompanyC uploads an empty file named *RedCapComplexityFLS6-v003-CompanyB-CompanyC.checkout*
* CompanyC then has 30 minutes to upload *RedCapComplexityFLS6-v003-CompanyB-CompanyC.docx*
* If no update is uploaded in 30 minutes, other companies can ignore the checkout file.
* Note that the file timestamps on the server are in UTC time.

The structure of this document follows the structure in TR 38.875 V0.0.3 ([R1-2009490](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009490.zip)). The tables with device cost evaluation results in this contribution will be updated as needed with new evaluation results from the email discussion [103-e-NR-RedCap-EvaluationResults].

# 6 Evaluation methodology

## 6.1 Evaluation methodology for UE complexity reduction

RAN1#103e agreements:

* For averaging of cost estimates, take the average of all values.
* Adopt the updated TP in Proposal 6.1-1e in R1-2009651 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/R1-2009651.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009651.zip)) for TR clause 6.1.

# 7 UE complexity reduction features

## 7.1 Introduction to UE complexity reduction features

The following TP on introduction to UE complexity reduction features can be considered.

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| The following UE complexity reduction techniques have been studied:   * Reduced number of UE Rx branches * UE bandwidth reduction * Half-duplex FDD operation * Relaxed UE processing time * Relaxed maximum number of MIMO layers * Relaxed maximum modulation order   The evaluation results for each one of the studied individual UE complexity reduction techniques is captured in clauses 7.2 through 7.7, respectively. The properties of combinations of different individual UE complexity reduction techniques are described in clause 7.8. |

**FL3: Phase 3: Question 7.1-1: Can the above TP on introduction to UE complexity reduction features be used as a baseline text for TR 38.875?**

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| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| vivo | Y |  |
| Samsung | Y |  |
| NEC | Y |  |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| Xiaomi | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| Qualcomm | Y |  |
| Intel | Y |  |

## 7.2 Reduced number of UE Rx branches

### 7.2.1 Description of feature

RAN1#103e agreement:

* Adopt the TP in [R1-2009393](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009393.zip) for TR clause 7.2.1.

### 7.2.2 Analysis of UE complexity reduction

RAN1#103e agreements:

* Adopt the description in Proposal 7.2.2-1 in R1-2009651 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/R1-2009651.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009651.zip)) of the benefit of reduced number of UE Rx branches in terms of reducing the device size in FR1 as a baseline text for TR 38.875.
* Adopt the description in Proposal 7.2.2-2 in R1-2009651 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/R1-2009651.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009651.zip)) of the benefit of reduced number of UE Rx branches in terms of reducing the device size in FR2 as a baseline text for TR 38.875.

The tables with device cost evaluation results in this contribution are based on [RedCapCost-v048-FL-Samsung2.xlsx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/drafts/8.6/EvaluationResults/RedCapCost/RedCapCost-v048-FL-Samsung2.xlsx). They will eventually be updated with new results from the email discussion [103-e-NR-RedCap-EvaluationResults].

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| When the number of UE Rx branches is reduced, the maximum number of DL MIMO layers is reduced correspondingly. For study purposes, two sets of evaluation results are presented below. The first set concerns the estimated cost reduction from reducing the number of Rx branches without taking the reduced maximum number of downlink MIMO layers into account, whereas the second set considers both the reduced number of Rx branches and the corresponding reduction of the maximum number of DL MIMO layers.  The estimated cost for a device with reduced number of UE Rx branches without taking reduced number of downlink MIMO layers into consideration, relative to the reference NR device (see evaluation methodology described in clause 6.1) and averaged over the results provided by the sourcing companies, is summarized in Table 7.2.2-1. As can be seen in the last row for the total cost, the average estimated cost reduction achieved by reducing the number of UE Rx branches are as follows:   * FR1 FDD (2Rx 🡪 1Rx): ~26% * FR1 TDD (4Rx 🡪 2Rx): ~31% * FR1 TDD (4Rx 🡪 1Rx): ~46% * FR2 TDD (2Rx 🡪 1Rx): ~31%   By comparing Table 7.2.2-1 with the reference NR device cost breakdown in clause 6.1, it can be observed that the main contributors of the cost reduction are the following functional blocks:   * RF: Antenna array (only FR2) * RF: Filters * RF: Transceiver (including LNAs, mixer, and local oscillator) * Baseband: ADC/DAC * Baseband: FFT/IFFT * Baseband: Post-FFT data buffering * Baseband: Receiver processing block * Baseband: Synchronization/cell search block   Furthermore, all sourcing companies indicated that the RF cost savings (but not the baseband cost savings) from reducing the number of UE Rx branches accumulate across supported bands in both FR1 and FR2.  **Table 7.2.2-1: Estimated relative device cost for reduced number of UE Rx branches**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Reduced number of UE Rx branches** | **FR1 FDD**  **(2Rx 🡪 1Rx)** | **FR1 TDD**  **(4Rx 🡪** **2Rx)** | **FR1 TDD**  **(4Rx 🡪 1Rx)** | **FR2 TDD**  **(2Rx 🡪 1Rx)** | | RF: Antenna array | - | - | - | 18.2% | | RF: Power amplifier | 25.0% | 25.0% | 25.0% | 18.0% | | RF: Filters | 4.8% | 7.6% | 3.9% | 4.3% | | RF: Transceiver (including LNAs, mixer, and local oscillator) | 25.3% | 30.4% | 17.8% | 23.7% | | RF: Duplexer / Switch | 19.6% | 4.9% | 4.9% | 0.0% | | **RF: Total relative cost** | **74.7%** | **67.9%** | **51.6%** | **64.2%** | | BB: ADC / DAC | 6.4% | 5.2% | 3.4% | 2.4% | | BB: FFT/IFFT | 2.3% | 2.2% | 1.3% | 2.2% | | BB: Post-FFT data buffering | 5.6% | 5.3% | 3.0% | 6.0% | | BB: Receiver processing block | 13.7% | 15.7% | 9.0% | 13.3% | | BB: LDPC decoding | 9.7% | 8.7% | 8.6% | 8.6% | | BB: HARQ buffer | 13.6% | 11.6% | 11.4% | 10.5% | | BB: DL control processing & decoder | 4.9% | 4.0% | 3.9% | 4.9% | | BB: Synchronization / cell search block | 5.1% | 4.8% | 2.7% | 3.8% | | BB: UL processing block | 5.0% | 5.0% | 5.0% | 7.0% | | BB: MIMO specific processing blocks | 8.2% | 7.9% | 7.3% | 15.8% | | **BB: Total relative cost** | **74.4%** | **70.4%** | **55.7%** | **74.5%** | | **RF+BB: Total relative cost** | **74.5%** | **69.4%** | **54.0%** | **69.4%** |   The estimated cost for a device with reduced number of UE Rx branches and a corresponding reduction of the number of downlink MIMO layers, relative to the reference NR device (see evaluation methodology described in clause 6.1) and averaged over the results provided by the sourcing companies, is summarized in Table 7.2.2-2. As can be seen in the last row for the total cost, the average estimated cost reduction achieved by reducing the number of UE Rx branches and MIMO layers are as follows:   * FR1 FDD (2Rx 🡪 1Rx): ~37% * FR1 TDD (4Rx 🡪 2Rx): ~40% * FR1 TDD (4Rx 🡪 1Rx): ~60% * FR2 TDD (2Rx 🡪 1Rx): ~40%   By comparing Table 7.2.2-2 with the reference NR device cost breakdown in clause 6.1, it can be observed that the main contributors of the cost reduction are the following functional blocks:   * RF: Antenna array (only FR2) * RF: Filters * RF: Transceiver (including LNAs, mixer, and local oscillator) * Baseband: ADC/DAC * Baseband: FFT/IFFT * Baseband: Post-FFT data buffering * Baseband: Receiver processing block * Baseband: LDPC decoding * Baseband: HARQ buffer * Baseband: Synchronization/cell search block * Baseband: MIMO specific processing blocks   Furthermore, all sourcing companies indicated that the RF cost savings (but not the baseband cost savings) from reducing the number of UE Rx branches accumulate across supported bands in both FR1 and FR2, whereas the cost savings from reducing the number of downlink MIMO layers do not.  **Table 7.2.2-2: Estimated relative device cost for reduced number of UE Rx branches and a corresponding reduction of the supported maximum number of MIMO layers**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Reduced number of UE Rx branches and MIMO layers** | **FR1 FDD**  **(2Rx 🡪 1Rx)** | **FR1 TDD**  **(4Rx 🡪** **2Rx)** | **FR1 TDD**  **(4Rx 🡪 1Rx)** | **FR2 TDD**  **(2Rx 🡪 1Rx)** | | RF: Antenna array | - | - | - | 18.7% | | RF: Power amplifier | 25.0% | 25.0% | 25.0% | 18.0% | | RF: Filters | 5.2% | 7.6% | 4.0% | 4.4% | | RF: Transceiver (including LNAs, mixer, and local oscillator) | 24.6% | 30.4% | 17.4% | 23.8% | | RF: Duplexer / Switch | 19.5% | 4.9% | 4.8% | 0.0% | | **RF: Total relative cost** | **74.2%** | **68.0%** | **51.3%** | **64.9%** | | BB: ADC / DAC | 5.9% | 5.0% | 3.1% | 2.3% | | BB: FFT/IFFT | 2.1% | 2.1% | 1.1% | 2.1% | | BB: Post-FFT data buffering | 5.0% | 5.0% | 2.5% | 5.5% | | BB: Receiver processing block | 12.1% | 14.6% | 7.5% | 12.1% | | BB: LDPC decoding | 5.0% | 4.5% | 2.3% | 4.5% | | BB: HARQ buffer | 7.2% | 6.1% | 3.1% | 5.7% | | BB: DL control processing & decoder | 5.0% | 4.0% | 4.0% | 5.0% | | BB: Synchronization / cell search block | 4.5% | 4.5% | 2.3% | 3.5% | | BB: UL processing block | 5.0% | 5.0% | 5.0% | 7.0% | | BB: MIMO specific processing blocks | 4.1% | 4.5% | 2.0% | 8.0% | | **BB: Total relative cost** | **55.9%** | **55.4%** | **33.0%** | **55.7%** | | **RF+BB: Total relative cost** | **63.2%** | **60.4%** | **40.3%** | **60.3%** | |

Since RAN1#103e has agreed to collect cost estimates for reduced number of Rx branches including corresponding reduction of number of MIMO layers, the TP for TR clause 7.2.2 can be updated to capture these estimates.

**Phase 1: Proposal 7.2.2-1b: Adopt the TP above as baseline text for TR clause 7.2.2, where the tables will be updated according to [103-e-NR-RedCap-EvaluationResults].**

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| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Huawei, HiSilicon | Y | It is Ok to state that “a corresponding reduction of the supported maximum number of downlink MIMO layers”, while in our estimate we will not reduce the MIMO layers in baseband, as reduction of Rx results in reduced MIMO layers of the entire UE already. The cost increment by a specialized single Layer chipset for e.g. FDD plus a two-Layer chipset for e.g. TDD, is not cost-efficient compared to a two-Layer chipset used across multiple bands, and thus not our implementation. |
| CATT | Y |  |
| CMCC | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| vivo | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | Y |  |
| Qualcomm | Y |  |
| DOCOMO | Y |  |
| Sierra Wireless | Y |  |
| Samsung | N | Suggest to delete table 7.2.2.-1 and corresponding descriptions. And added analysis on cost saving for main contributors for table 7.2.2-2  Suggested changes as below:  ~~Table 7.2.2-1 summarizes the estimated cost for a device with reduced number of Rx branches without taking reduced number of downlink MIMO layers into consideration, relative to the reference NR device (see evaluation methodology described in clause 6.1) and averaged over the results provided by the sourcing companies.~~  Table 7.2.2-2 summarizes the estimated cost for a device with reduced number of Rx branches and a corresponding reduction of the supported maximum number of downlink MIMO layers, relative to the reference NR device (see evaluation methodology described in clause 6.1) and averaged over the results provided by the sourcing companies.  By comparing Table 7.2.2-2~~1~~ with the reference NR device cost breakdown in clause 6.1, it can be observed that the main contributors of the cost reduction are the following functional blocks:   * RF: Antenna array (only FR2) * RF: Filters * RF: Transceiver (including LNAs, mixer, and local oscillator) * Baseband: ADC/DAC * Baseband: FFT/IFFT * Baseband: Post-FFT data buffering * Baseband: Receiver processing block * Baseband: LDPC decoding * Baseband: HARQ buffer * Baseband: Synchronization/cell search block * Baseband: MIMO specific processing blocks |
| Ericsson | Y |  |
| Intel | Y |  |
| Spreadtrum | Y |  |
| OPPO | Y |  |
| FL | The TP above has been updated based on the received responses.  **FL1: Phase 1: Proposal 7.2.2-1c: Adopt the TP above as baseline text for TR clause 7.2.2.** | |
| FUTUREWEI2 | Y |  |
| MediaTek | Y |  |
| Ericsson | Y |  |
| Qualcomm | Y |  |
| Intel | Y |  |
| Nokia, NSB | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| CATT | Y |  |
| SONY6 | Y |  |
| CMCC | Y |  |
| ZTE | Y |  |
| OPPO | Y |  |
| Samsung |  | If all other companies insist to capture Rx reduction without MIMO layer reduction, we like to add a sentence in the description:  Note that, reduced of the number of UE Rx branches will naturally reduced the max support of MIMO layers. That is, the supported of MIMO layer cannot be larger than the number of UE Rx branches. |
| Huawei, HiSilicon | Y |  |
| Spreadtrum | Y |  |
| FL | The TP above has been updated based on the received responses.  **FL3: Phase 1: Proposal 7.2.2-1d: Adopt the TP above as baseline text for TR clause 7.2.2.** | |
| Ericsson | Y |  |
| Samsung | Y | Thanks for the update. For the sake of progress, we can accept with this version. |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| Xiaomi | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| Qualcomm | Y |  |
| MediaTek | Y |  |
| Intel | Y |  |

### 7.2.3 Analysis of performance impacts

RAN1#103e agreement:

* TPs corresponding to Questions 7.2.3-2/3a/4a/5a/7a in R1-2009651 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/R1-2009651.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009651.zip)).

**Power consumption:**

* P4: [4] and [16] have noted that power consumption is also saved by fewer RF chains and by less complexity of multi-antenna processing. In [6], it has been noted that the power consumption of 1 Rx UE is lower than that of a 2 Rx UE.
* P5: [1, 11, 13, 15, 19, 27, 28] have noted that although the reduction in Rx antenna can reduce power consumption in the RF and the baseband modules, due to longer reception time needed for downlink channels, the power consumption will be increased. In [1, 15], it has been highlighted that the actual impact depends on the DL traffic.
* P6: The evaluation results in [4] show that the power saving gains when reducing the number of UE Rx antennas from 2 to 1 are about 14% for instant messaging traffic, 11% for Heartbeat traffic and 15% for VoIP traffic. In [24], it has been mentioned that more evaluations are needed to understand the impact on overall power consumption due to lower consumption in RF/baseband modules and longer reception time.

Based on submitted contributions and email discussion responses, the following TP can be considered.

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| --- |
| **Power consumption:**  The instantenous power consumption in the RF and the baseband modules of the UE is expected to be reduced due to the use of fewer RF chains and the reduction in the complexity of multi-antenna processing. However, depending on the traffic characteristics, the average power consumption of the UE can increase or decrease. The reason why the average power consumption may potentially increase is that the reduced downlink spectral efficiency may require a longer reception time for the PDSCH to deliver the same amount of data. |

**Phase 2: Question 7.2.3-6: Can the above observations of the impact on power consumption for reduced number of UE Rx antennas be used as a baseline text for TR 38.875?**

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| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| ZTE | Y |  |
| vivo | N | Regarding the last sentence, it seems no evaluation results showing that with what traffic model, the average power consumption will increase due to reduced Rx? |
| SONY5 | Y | Editorial: “fewer ~~number of~~ RF chains”.  In response to vivo: if the reduced number of RX antennas caused a halving of MCS, then the UE would have to be “on” for twice as long to receive the data. This would tend to increase the power consumption. A related observation was made in TR36.888 (section 6.3.2.2): “*Reduced downlink spectral efficiency would require larger coded blocks or a longer reception time for the PDSCH to deliver the same amount of data. This would increase the average power consumption*”. We think that this effect occurs both in LTE and in NR. |
| FUTUREWEI | Y | This balanced style of observation seems fair and about as good as we can get. |
| DOCOMO | Y |  |
| Sierra Wireless | Y |  |
| Samsung |  | The observation can be made based on the result in AI 8.6.2 |
| Ericsson | Y |  |
| Intel | N | Agree with Vivo that the “increase” part is not very obvious and such may not occur in many cases. Reduction in Rx antenna may not necessarily lead to longer DL reception. The UE could still be scheduled over the same time resources with larger BW or with power boosting. Thus, further conditioning/clarifications would be necessary if we want to capture possibility of power consumption increase. |
| OPPO | N | Agree with vivo. The last sentence shall be further proved? |
| Xiaomi | Y |  |
| CATT | Y |  |
| LG | N | Agree with the comments above from vivo, Intel and OPPO. |
| Huawei, HiSilicon | FFS | The last sentence is being studied in other sessions. May need to calrify as vivo commented. |
| FL | The proposal has been updated based on received responses.  **FL2: Phase 2: Question 7.2.3-6a: Can the above observations of the impact on power consumption for reduced number of UE Rx antennas be used as a baseline text for TR 38.875?** | |
| CATT | Y |  |
| Qualcomm | N | Need to align with the outcome of AI 8.6.2 |
| vivo | N | We disagree with the updated proposal. As commented before, there is no evaluation results showing that reduced Rx can actually increase UE power consumption. However, we had provided simuatio results in R1-2009212 section 2.3 showing that reducing Rx can provide power saving benefit based on the agreed agreed power model and traffic mode. |
| ZTE | Y |  |
| Samsung |  | We think P6 is worthwhile to capture. So, some changes is proposed:  The instantenous power consumption in the RF and the baseband modules of the UE is expected to be reduced due to the use of fewer RF chains and the reduction in the complexity of multi-antenna processing. ~~However, depending on the traffic characteristics, the average power consumption of the UE can increase or decrease.~~ The average power consumption may increase since the reduced downlink spectral efficiency may require larger coded blocks or a longer reception time for the PDSCH to deliver the same amount of data. However, for typical traffic for Redcap UE, i.e., instant messaging traffic, Heartbeat traffic and VoIP traffic, 11%~15% of power saving is observed by one soucing company.  In addition, we suggest to clarify that the TP can be updated based on output of AI 8.6.2 |
| Huawei, HiSilicon | Y |  |
| Spreadtrum | Y |  |
| LG | N | We don’t agree on this analysis. Larger coded bits given the same amount of payload and slightly increased number of repetitions doesn’t always result in net incease in the power consumption. It would be okay to us if the last two sentences (or at least the last sentence) are removed. |
| FUTUREWEI3 | Y |  |
| Ericsson | Y | Regarding the last sentence proposed by Samsung, if the evaluations have been made under the assumption that the traffic is DL only, we think that would need to be clarified in the sentence if any such sentence is to be included. We prefer to not include any quantitative analysis here. |
| SONY7 | Y | Agree with proposal.  Agree with Ericsson about quantitative analysis in these sections: the text in these 7.x.3 sections tends to be more qualitative than quantitative.  A couple of responses to comments from other companies:  Vivo: do you disagree with the text in TR36.888 (section 6.3.2.2): “*Reduced downlink spectral efficiency would require larger coded blocks or a longer reception time for the PDSCH to deliver the same amount of data. This would increase the average power consumption*”? Why would we reach a different conclusion for NR relative to LTE?  LG: Regarding the red part of your comment: “Larger coded bits given the same amount of payload and slightly increased number of repetitions doesn’t always result in net incease in the power consumption.”. We think the FL proposal doesn’t contradict your point (see red, again): “The average power consumption may increase” |
| Intel | N | Larger coded blocks do not necessarily imply longer PDSCH, and perhaps more importantly, even if PDSCH duration may increase (say, by a few symbols), still overall UE power consumption may not.  Following the logic of “longer DL reception” causing overall power consumption increase could only occur if the reference configuration is already using repetitions (slot aggregation) and not for typical coverage scenarios. Thus, such conditioning may be needed if we have to capture something. |
| FL | The proposal has been updated based on received responses.  **FL3: Phase 2: Question 7.2.3-6b: Can the above observations of the impact on power consumption for reduced number of UE Rx antennas be used as a baseline text for TR 38.875?** | |
| Ericsson | Y |  |
| vivo | Object | The reaon for objection has been provided in earlier feedback. We can live with deleting the 2nd and 3rd sentence and keep the first sentence only.  **Power consumption:**  The instantenous power consumption in the RF and the baseband modules of the UE is expected to be reduced due to the use of fewer RF chains and the reduction in the complexity of multi-antenna processing. ~~However, depending on the traffic characteristics, the average power consumption of the UE can increase or decrease. The reason why the average power consumption may potentially increase is that the reduced downlink spectral efficiency may require a longer reception time for the PDSCH to deliver the same amount of data.~~ |
| Samsung |  | We support Vivo’s suggestion. |
| NEC | Y |  |
| CATT | Y |  |
| DOCOMO | Y |  |
| Xiaomi |  | vivo has provided simulation results to show there is power consumption reduction, while there is no other contribution to show there is power consumption increase. So the statement of *“depending on the traffic characteristics, the average power consumption of the UE can increase or decrease. The reason why the average power consumption may potentially increase is that the reduced downlink spectral efficiency may require a longer reception time for the PDSCH to deliver the same amount of data”* is not well justified. Considering this fact, we support vivo’s suggestion |
| LG |  | We prefer to remove the last two sentences as suggested by vivo. |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| FUTUREWEI4 | Y | The view needs to be balanced, and not only capture that it may decrease but also the concern that it could increase or decrease depending on traffic. Same comment for antenna reduction and bandwidth reduction. |
| Qualcomm | N | We agree with Vivo’s comments |
| MediaTek | Y |  |
| Intel | N | Same view as expressed before, and support the proposal from Vivo. |

### 7.2.4 Analysis of coexistence with legacy UEs

The following potential coexistence impacts were identified in the contributions:

* C1: There will be coexistence impact depending on the coverage recovery solutions and other enhancements (e.g., early RedCap indication in RACH) adopted for RedCap during the initial access stage [1, 2, 5, 9, 11, 15, 21, 24]. Note that depending on the outcome of discussions taking place under AI 8.6.3, no coverage recovery may be needed to compensate for the performance loss due to reduced number of UE Rx antennas.
* C2: Blocking impacts if RedCap UE need to use higher aggregation levels for PDCCH reception [1, 2, 5, 24].
* C3: There will be coexistence issues if common DL broadcast channels (e.g., SIBx/RAR/paging) are used for both legacy UEs and RedCap UEs [1, 5, 15, 16, 24]. This is because the system treating the UEs the same will mean conservative handling of all UEs. It has also been noted in [16] that the common channels can be transmitted separately for redcap UE and normal NR UE, which can be realized by the gNB’s scheduling implementation.
* C4: RedCap UEs with reduced number of Rx antennas can coexist with legacy UEs in general [4, 11, 15, 16, 19].
* C5: The network deployment (cell planning) may be required to be adjusted [24]. It is also been mentioned in [24] that this aspect can be considered in RAN4.
* C6: 1 Rx RedCap UEs would cause significant performance degradation to legacy UEs due to coexistence needs or may cause network block for RedCap UEs accessing when the number of UEs in one cell is large [3].

The FL understanding is that the potential coexistence impacts C1 and C2 can be addressed in the TR sections related to other AIs, more specifically:

* C2 🡪 AI 8.6.2
* C1 🡪 AI 8.6.3 & AI 8.6.5

Based on submitted contributions and email discussion responses, the following TP on coexistence impacts can be considered.

|  |
| --- |
| In general, RedCap UEs with reduced number of Rx branches can coexist with legacy UEs. However, the presence of RedCap UEs with reduced number of Rx branches may impact the performance for legacy UEs if broadcast channels such as those used for transmitting system information blocks, random access responses and paging messages are used for both legacy UEs and RedCap UEs. This is because, depending on the network implementation, both legacy UEs and RedCap UEs may be treated the same by the network, which may lead to conservative treatment of all UEs. |

**FL3: Phase 3: Question 7.2.4-2: Can the above observations of the coexistence impacts for reduced number of UE Rx antennas be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| Samsung |  | We think AI 8.6.3 may focus on whether a certain coverage can be achieved for a certain channel/message. We sugget to provide some general description here. As we commented in email thread [04], there may have some issues to find enough DL resource especially when assuming all UE might be Redcap. Therefore, we suggest the following change:  In general, RedCap UEs with reduced number of Rx branches can coexist with legacy UEs. However, the presence of RedCap UEs with reduced number of Rx branches may impact the performance for legacy UEs if broadcast channels such as those used for transmitting system information blocks, random access responses and paging messages are used for both legacy UEs and RedCap UEs. This is because, depending on the network implementation, both legacy UEs and RedCap UEs may be treated the same by the network, which may lead to conservative treatment of all UEs. Besides, since more resources are needed for DL common channels due to Rx reduction, e.g., PDCCH, Msg2, Msg4, paing, and these DL common channels are restricted to CORESET 0 bandwith, it may be hard to find sufficient DL resources especially for FR2. |
| FL | Clarification: Note that the question concerns the TP right above the question, not the bullet lists above the TP. | |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE |  | if broadcast channels such as those used for transmitting system information blocksare used for both legacy UEs and RedCap UEs |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| FUTUREWEI4 |  | Some mention of possible blocking increase should be mentions (related to C2) |
| Qualcomm | N | We suggest the following changes for the TP:  In general, RedCap UEs with reduced number of Rx branches can coexist with legacy UEs. However, the presence of RedCap UEs with reduced number of Rx branches may impact the performance for legacy UEs if broadcast channels such as those used for transmitting system information blocks, random access responses and paging messages are used for both legacy UEs and RedCap UEs. This is because, without indication of RedCap UE, depending on the network implementation, both legacy UEs and RedCap UEs will may be treated the same by the network, which may lead to conservative treatment of all UEs. |
| Intel | Y |  |

### 7.2.5 Analysis of specification impacts

**RAN1/RAN2 specification impacts:**

The following potential RAN1/RAN2 specification impacts were identified in the contributions:

* S1: PDCCH repetition: [12, 15, 22, 24]
* S2: Additional repetitions for PDSCH: [12, 22, 24]
* S3: AL greater than 16: [11, 15, 24]
* S4: Compact DCI: [15, 24]
* S5: CSI report enhancement to improve spectral efficiency: [15]
* S6: Early indication of RedCap UE in random access: [1, 22, 15]
* S7: Group scheduling to reduce PDCCH overhead and solve PDCCH blocking issue [15]
* S8: Cross-repetition channel estimation [12]

Several contributions [1, 2, 3, 4, 5, 9, 11, 12, 13, 15, 16, 19, 20, 21, 22, 23, 24, 28] point out the specification impacts from reducing the number of UE Rx antennas. Potential RAN1 impacts depend on the techniques that may be used to compensate for the coverage and spectral efficiency loss. The extent of RAN1 impacts would also depend on the outcome of link budget analysis that is taking place under AI 8.6.3.

It has been noted in [3] that depending on the performance target, e.g., peak data rate and coverage recovery, there could be no/marginal specification impacts for UEs with 2Rx (20MHz) but there would be specification impact for 1Rx UEs even with larger bandwidth (for coverage/throughput improvement).

In addition, [19] has indicated that there would be potential RAN2 impact due to signalling of reduced antenna capability. It has also been noted in [1] that early indication (S6) will also have RAN2 specification impacts.

The FL understanding is that the potential RAN1/RAN2 specification impacts (S1-S8) can be addressed in the TR sections related to other AIs, more specifically:

* S1, S2, S3, S4, S5, S7, S8 🡪 AI 8.6.3
* S6 🡪 AI 8.6.5

**RAN4 specification impacts:**

Several contributions [1, 2, 4, 5, 13, 15, 16, 19, 20, 28] have mainly also highlighted potential RAN4 specification impacts, including RRM, receiver characteristics, demodulation performance requirements, CSI reporting requirements, RF, and procedure requirements (e.g., cell change, radio link management, beam management, etc.). It is also mentioned in [5] that RAN4 needs to evaluate and specify the new minimum number of Rx antennas for different bands. In [5], it also suggested that UL transmit antenna gain should be evaluated in RAN4 for size-limited RedCap UEs, e.g. some wearables. In [1, 28], it is indicated that the impact is more significant when reducing the number of receiver branches to 1. It has been mentioned in [1] that the impacts are manageable and comparable (at least for FR1) to the corresponding changes done for Cat M1 UEs in LTE.

Based on submitted contributions and email discussion responses, the following TP on specification impacts can be considered.

|  |
| --- |
| For reduced number of Rx branches, work in RAN4 will be required to define new receiver characteristics, demodulation performance requirements, and requirements relating to CSI reporting, RF, RRM, and other procedures, such as cell change, radio link management and beam management. RAN4 may also need to evaluate and specify new minimum numbers of Rx branches for RedCap UEs in different bands. Impacts on RAN4 specifications may also extend beyond the mentioned aspects. |

**FL3: Phase 3: Question 7.2.5-2: Can the above observations of specification impacts of reduced number of UE Rx antennas be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| Samsung |  | For RAN 1/2 spec impact, we sugget to add from all over system operation perpective.  In order to find sufficient resource for DL common channels, e.g. Msg2/4, dedicated initial BWP(s), removing the restriction of PDSCH within COREST 0 bandwithd can be considered. |
| NEC | Y |  |
| FL | Clarification: Note that the question concerns the TP right above the question, not the bullet lists above the TP. | |
| CATT | Y mostly | Not sure what ‘cell change’ exactly means. Does it mean ‘cell ~~change~~ handover or (re-)selection’? |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY |  | Shouldn’t we have some sort of text that says that there will be RAN1 specification impacts and these are considered in clauses 8.6.3 and 8.6.5? At the moment, it sounds like there are no RAN1 specification impacts. Something like “For reduced number of RX branches, there would be some potential RAN1 specification impacts related to coverage recovery and initial access. These are considered in clauses 8.6.3 and 8.6.5”.  For the TP, should we mandate what RAN4 need to do, or should they (or RANP) decide? It is also not clear to us that all of the listed RAN4 impacts are required (e.g. for CSI reporting, it seems like the UE would be reporting worse CSI values, but there doesn’t need to be a spec change. However, we don’t want to get into discussing all these details). We suggest this potential change.  “For reduced number of Rx branches, work in RAN4 ~~will~~ may be required…” |
| Qualcomm | Y | We are studying a new set of UE capabilities for cost/complexity reduction, which will bring new use cases and business opportunities for 5G.  The involvement of RAN4 is necessary when appropriate, and should not be treated as a negative impact for introducing reduced number of RX branches. |
| Intel | Y |  |

## 7.3 UE bandwidth reduction

### 7.3.1 Description of feature

RAN1#103e agreement:

* Adopt the TP in [R1-2009393](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009393.zip) for TR clause 7.3.1.

### 7.3.2 Analysis of UE complexity reduction

RAN1#103e agreement:

* Adopt the TP in [R1-2009393](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009393.zip) as baseline text for TR clause 7.3.2.
  + Companies are invited to double-check their entries in the cost reduction spreadsheet with respect to the above comments (and to catch potential typos).
  + The table will be further updated with potential updated cost estimates.

### 7.3.3 Analysis of performance impacts

RAN1#103e agreement:

* TPs corresponding to Questions 7.3.3-2/3a/5a/7a in R1-2009651 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/R1-2009651.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009651.zip)).

**Data rate:**

* P1: (FR1) There is an impact on peak data rate due to BW reduction [2, 15, 19, 20, 24].
* P2: (FR1) The most demanding DL peak rate requirements (150 Mbps) can be met by 20 MHz UE BW with 2 MIMO layers [3, 4, 6, 8, 10, 12, 14, 23, 24, 26].
* P3: (FR1) The most demanding DL peak rate requirements (150 Mbps) can be met by larger than 20 MHz UE BW, e.g. 40 MHz [4, 5, 8, 12, 26].
* P4: (FR1) The most demanding UL peak rate requirements (50 Mbps) can be met by 20 MHz UE BW [8].
* P5: (FR1) Single MIMO layer, 20 MHz UE BW, and 64QAM can meet the peak bit rate requirements of most use cases [1, 2, 4, 6, 8, 14, 26].
* P6: (FR2) All the data rate requirement can be met by 50 MHz and 100 MHz BW [1, 4, 14, 24].

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| **Data rate:**  Bandwidth reduction results in a reduction in the achievable peak data rate. However, all the bandwidth options (20 MHz in FR1, and 50 MHz or 100 MHz in FR2) considered in the RedCap study are enough for meeting the peak data rate requirements for the RedCap use cases, at least when the bandwidth reduction is not combined with other UE complexity reduction techniques. For peak rate impacts from combinations of UE complexity reduction techniques, see clause 7.8.3. |

**Phase 2: Question 7.3.3-4: Can the above observations of the impact on data rate for UE bandwidth reduction be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| LG | Y(partially) | Same concern as in **Phase 2: Question 7.2.3-4**. Consider changes suggested there. |
| ZTE | N | For 20 MHz in FR1, single-Rx RedCap UE cannot meet 150 Mbps peak data rate requirement. |
| vivo |  | Agree with ZTE’s point, maybe we should say “enough for meeting the peak data rate requirements for most of the RedCap use cases” |
| SONY5 | Y |  |
| FUTUREWEI | Y | The SID says “up to”. Let us not repeat that discussion. |
| Qualcomm |  | Agree with the suggestion of Vivo. |
| DOCOMO | Partially Y | Agree with LG |
| Sierra Wireless | Y | The proposal looks Ok. With the optional features the RedCap device should meet the requirements. For the highest of the rates, the SID says “up to”. |
| Samsung | Y |  |
| Ericsson | Y | Perhaps it can be clarified in the text that the statement concerns the individual technique, not combinations with other techniques. |
| Intel | Y |  |
| OPPO |  | Agree with ZTE and LG.  Vivo’s revision can be considered. |
| Xiaomi |  | Agree with ZTE and vivo |
| CATT | Y, partially | Like 7.2.3-4, we think ‘most of’ should be added before ‘the RedCap uses cases’. It is not sure whether all uses cases can be fulfilled, especially if the BW is also reduced (to 20MHz). |
| Huawei, HiSilicon | Y |  |
| FL | The proposal has been updated based on received responses.  **FL2: Phase 2: Question 7.3.3-4a: Can the above observations of the impact on data rate for UE bandwidth reduction be used as a baseline text for TR 38.875?** | |
| CATT | Y | We think it is somewhat obvious that the UE can fulfill the data rate requirement when only the BW is reduced. But we are fine with the current verson. |
| Qualcomm | Y |  |
| ZTE |  | Need to mention that only bandwidth is reduced |
| Samsung | Y |  |
| Huawei, HiSilion | Y |  |
| FUTUREWEI3 | Y |  |
| Ericsson | Y |  |
| SONY7 | Y |  |
| Intel | Y |  |
| FL | The proposal has been updated based on received responses.  **FL3: Phase 2: Question 7.3.3-4b: Can the above observations of the impact on data rate for UE bandwidth reduction be used as a baseline text for TR 38.875?** | |
| Ericsson | Y |  |
| NEC | Y |  |
| CATT | Y |  |
| CMCC | N | As the analysis in [9], for FR1 2.6GHz TDD, 64QAM, 2 layer can only achieve 40Mbps, which can not meet 50Mbps UL target date rate. We can not say “are enough for meeting the peak data rate requirements for the RedCap use cases” |
| DOCOMO | Y |  |
| LG | Y | As we agreed to support 2 Rx in FR1, we don’t don’t have a problem any more in terms preak bit rates. We are also okay without the newly added text. |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| Qualcomm | Y |  |
| MediaTek | Y |  |
| Intel | Y |  |

**Power consumption:**

* P18: UE bandwidth reduction may reduce power consumption [4, 11, 13].
* P19: Evaluation is needed to assess the effects of less RF/BB modules vs longer Rx time [19, 24].
* P20: There is no clear power consumption advantage or disadvantage due to UE bandwidth reduction. It may depend on the specific traffic scenario [1].
* P21: BW reduction has no impact on the power consumption of data channels [13].
* P22: In connected mode, when the RedCap UE operates in initial DL/UL BWP larger than maximum UE bandwidth of RedCap UEs, more power consumption would be expected due to RF retuning [5].

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| **Power consumption:**  UE bandwidth reduction reduces the instantaneous power consumption of the RF and baseband modules during transmission and reception. However, depending on the traffic characteristics, the average power consumption of the UE can increase or decrease. The reason why the average power consumption may potentially increase is that the reduced peak data rate may require a longer transmission/reception time for the PUSCH/PDSCH to deliver the same amount of data. |

**Phase 2: Question 7.3.3-6: Can the above observations of the impact on power consumption for UE bandwidth reduction be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| ZTE | Y |  |
| vivo |  | It is not clear whether increase of power consumption can be justified in the 2nd sentence. |
| SONY5 | Y | In response to vivo: if there is an increase in transmission time due to bandwidth reduction (either due to a lower MCS from frequency diversity loss, or due to a TB not “fitting into” 20MHz), then the UE needs to be “on” for longer, which would potentially cause an increase in power consumption. |
| FUTUREWEI | Y | Similar comment as before, balanced approach is appropriate. |
| DOCOMO | Y |  |
| Sierra Wireless | Y |  |
| Samsung | Y | Can be revised with observation in AI 8.6.3 |
| Ericsson | Y |  |
| Intel |  | We tend to agree with Vivo here.  While the proposes last sentence may be true in general, for the data rate requirements considered for RedCap, we are not sure if there would be an increase in power consumption with reduced UE BW (to 20 MHz and 100 MHz respectively). |
| OPPO |  | Agree with intel and vivo.  The last sentence shall be further proved. |
| Xiaomi | Y |  |
| CATT | Y |  |
| LG |  | Agree with vivo, Intel and OPPO. |
| Huawei, HiSilicon | Y | And also fine with vivo suggestion |
| FL | The proposal has been updated based on received responses.  **FL2: Phase 2: Question 7.3.3-6a: Can the above observations of the impact on power consumption for UE bandwidth reduction be used as a baseline text for TR 38.875?** | |
| CATT | Y |  |
| Qualcomm | FFS | Need to align with the outcome of AI 8.6.2 |
| vivo | N | We disagree with the updated proposal. Technically 20MHz can still provide enough data rate so that the active time for data transmission does not necessarily increase, especially for RedCap use case which typically has smaller data packets.  Since there are no evaluation results avaiable, we can go with more simpler version, i.e. 1st sentence only  **Power consumption:**  UE bandwidth reduction reduces the instantaneous power consumption of the RF and baseband modules during transmission and reception. ~~However, depending on the traffic characteristics, the average power consumption of the UE can increase or decrease. The average power consumption may increase since the reduced downlink peak data rate may require larger coded blocks or a longer reception time for the PDSCH to deliver the same amount of data.~~ |
| ZTE | Y |  |
| Samsung |  | Support vivo’s proposal |
| Huawei, HiSilion | Y |  |
| Spreadtrum | Y |  |
| LG | N | We don’t agree on this analysis. Larger coded bits given the same amount of payload and slightly increased number of repetitions doesn’t always result in net incease in the power consumption. We are okay with vivo’s suggestion. |
| FUTUREWEI3 | Y |  |
| Ericsson | Y |  |
| SONY7 | Y | Agree with proposal.  A couple of responses to comments from other companies:  Vivo: do you disagree with the text in TR36.888 (section 6.2.2.3): “*the reception time may become larger if the performance degradation on PDSCH results in a longer transmission time, thus possibly increasing the power consumption*”? Why would we reach a different conclusion for NR relative to LTE? We think we need to be talking about average power consumption, rather than instantaneous power consumption.  LG: Regarding the red part of your comment: “Larger coded bits given the same amount of payload and slightly increased number of repetitions doesn’t always result in net incease in the power consumption.”. We think the FL proposal doesn’t contradict your point (see red, again): “The average power consumption may increase”  the reception time may become larger if the performance degradation on PDSCH results in a longer transmission time, thus possibly increasing the power consumption |
| Intel | N | Agree with Vivo and support their proposed modification. See earlier comment regarding potential power consumption increase in the context of the possibilities of PDSCH with or w/o repetitions; the former cases (PDSCH with repetitions in reference UE case) not being the current focus for the current study. |
| FL | The proposal has been updated based on received responses.  **FL3: Phase 2: Question 7.3.3-6b: Can the above observations of the impact on power consumption for UE bandwidth reduction be used as a baseline text for TR 38.875?** | |
| Ericsson | Y |  |
| vivo | Object | The reason for objection is the same as before. We can live with keeping 1st sentence only.  **Power consumption:**  UE bandwidth reduction reduces the instantaneous power consumption of the RF and baseband modules during transmission and reception. ~~However, depending on the traffic characteristics, the average power consumption of the UE can increase or decrease. The average power consumption may increase since the reduced downlink peak data rate may require larger coded blocks or a longer reception time for the PDSCH to deliver the same amount of data.~~ |
| Samsung |  | We support vivo’s change |
| NEC | Y |  |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| Xiaomi |  | Vivo’s modification is fine to us |
| LG |  | We prefer to remove the last two sentences as suggested by vivo. |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| FUTUREWEI4 | Y | The view needs to be balanced, and not only capture that it may decrease but also the concern that it could increase or decrease depending on traffic. Same comment for antenna reduction and bandwidth reduction. |
| Qualcomm | N | Agree with the suggestion of Vivo. |
| MediaTek | Y |  |
| Intel | N | As explained in previous rounds, the last two sentences are not accurate in general. PDSCH/PUSCH durations may NOT increase, and even if they do, they may not increase power consumption unless we are dealing with a large numbers of repetitions which do not apply for the scenarios we are considering. We support the modification from Vivo. |

### 7.3.4 Analysis of coexistence with legacy UEs

The following potential coexistence impacts were identified in the contributions:

**General:**

* C1: (FR1) For FR1, with 20MHz bandwidth capability, Redcap UEs should be able to coexist with the legacy UE [1, 11, 16, 19].
* C2: (FR2) For FR2, with 100MHz bandwidth capability, there is no coexistence impact [1, 11, 16].
* C3: There may or may not be impacts on the coexistence with legacy UEs, depending on the cell load and the solutions for RedCap and normal UEs camped on the same cell [4].

**Initial access and initial BWP:**

* C4: There may be issues with frequency-division multiplexed RACH Occasions [24].
* C5: (FR1) For initial access in FR1, the RedCap UEs can share SSB, SIB1, other SIs, RAR and Msg4 configured for normal NR UEs [5].
* C6: (FR2) The RedCap UEs with 100 MHz maximum UE bandwidth can share SSB, SIB1, other SIs, RAR and Msg4 configured for normal NR UEs [5].
* C7: (FR2) Compared with maximum UE bandwidth of 100 MHz, to support the RedCap UEs with 50 MHz maximum UE bandwidth, more serious configuration or scheduling restrictions to normal NR UEs would be expected. It may reduce the configuration or scheduling flexibility of legacy NR UEs [5].
* C8: Separate SIB1 for RedCap devices can be configured to solve coexistence problems [9].
* C9: (FR2) Limiting the supported SCS combinations for SSB/CORESET0 may be considered [9].
* C10: (FR2) There may be issues, such as backward compatibility or configuration restriction, with SSB and CORESET0 for supporting RedCap UE with 50MHz bandwidth [2, 4, 8, 15, 17, 23, 24].
  + Two initial access procedures will have to coexist: one for ‘regular’ UEs, one for RedCap UEs [2].
* C11: (FR2) With 50MHz UE BW, there may be misalignment between Redcap UE’s receiving bandwidth and the scheduling bandwidth of PDSCH for common channel during initial access procedure [16].
* C12: Supporting RedCap UEs may result in a high load in the initial BWP [24].
* C13: RedCap UEs may not support the bandwidth of the initial UL BWP configured for normal UEs in SIB1 depending on Rel-15 cell configuration [1, 5, 8, 9, 10].
  + This impacts Msg3 [1, 5] and PUCCH for Msg4 [1].
  + A separate UL BWP for RedCap devices can be configured to solve coexistence problems [9].
* C14: For both IDLE/INACTIVE and RRC-CONNECTED modes, if RedCap UEs are offloaded to a different BWP than initial BWP, it is beneficial from UE implementation perspective to have SSB transmitted in the operating BWP for RedCap UEs [4].

**Other aspects:**

* C15: Paging capacity may be an issue [24].
* C16: (FR2) In Idle mode, if the maximum UE bandwidth of RedCap UEs is 50 MHz, paging configuration for normal NR UEs may need to be restricted if the RedCap UEs and normal NR UEs share the same paging resources [5].
* C17: PDCCH blocking probability will increase with bandwidth reduction [15].
* C18: A reduced bandwidth Redcap UE is unable to measure the PRS across a wide bandwidth [19].
* C19: Legacy UE performance might be impacted if RedCap UEs accessing the cell with full backward compatibility [17].
* C20: RedCap UEs performance might not be guaranteed if accessing the cell with full backward compatibility. [17].

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| In general, UE bandwidth options such as 20 MHz for FR1 UEs and 100 MHz for FR2 UEs achieve good coexistence performance with legacy UEs.   * The 20-MHz bandwidth option for FR1 UEs allows a RedCap UEs to reuse existing procedures for acquiring SSB, SIB1, other SIBs, RAR and Msg4. * The 100-MHz bandwidth option for FR2 UEs achieves the same coexistence benefits, except that for certain configurations for SSB/CORESET multiplexing patterns 2 and 3, the UE needs to acquire SSB and SIB1 in a sequential manner. However, the sequential SSB/SIB1 acqisition for a RedCap UE does not cause any performance degradation to legacy UEs. * The 50-MHz bandwidth option for FR2 UEs would result in coverage loss for PDCCH reception in CORESET#0 if CORESET#0 is configured to 69.12 MHz. In such cases, if coverage recovery is needed for PDCCH, PDCCH capacity of CORESET#0 may be affected, and this will have impact on legacy UEs. Furthermore, if early RedCap UE identification is not provided, supporting 50-MHz RedCap UEs requires the gNB to schedule the PDSCH of SIBs, RAR, and Msg4 within 50 MHz bandwidth. Such scheduling restrictions will have an impact on legacy UEs.   The following additional issues have been identified as potential coexistence issues introduced by RedCap UE bandwidth reduction.   * Frequency-division multiplexed (FDM) RACH Occasions (RO) may have a total frequency span greater than the RedCap UE bandwidth. This may result in restrictions in the configuration of FDM ROs, which have an impact on legacy UEs. * Some of the initial UL BWP configurations have a larger bandwidth than the bandwidth options considered for RedCap. This would have impact on Msg3 and PUCCH for Msg4 for RedCap UEs. If the network is restricted to use UL BWP configurations that have a bandwidth no greater than the RedCap UE bandwidth capability also for legacy UEs, there would be impacts on Msg3 and PUCCH for Msg4 for legacy UEs. |

**FL3: Phase 3: Question 7.3.4-2: Can the above observations of coexistence impacts of UE bandwidth reduction be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| vivo | comments | We have comments on the additional issues proposed  The following additional issues have been identified as potential coexistence issues introduced by RedCap UE bandwidth reduction.   * Frequency-division multiplexed (FDM) RACH Occasions (RO) may have a total frequency span greater than the RedCap UE bandwidth. This may result in restrictions in the configuration of FDM ROs, which have an impact on legacy UEs.   [vivo] We think spec allows network to handle this case by implementation (configuring the mapping between SSB and FDMed RO properly), as long as there is RO available within the RedCap BW associated with each SSB index, so that network does not need to restrict the FDM configuration of RO for eMBB UEs   * Some of the initial UL BWP configurations have a larger bandwidth than the bandwidth options considered for RedCap. This would have impact on Msg3 and PUCCH for Msg4 for RedCap UEs. If the network is restricted to use UL BWP configurations that have a bandwidth no greater than the RedCap UE bandwidth capability also for legacy UEs, there would be impacts on Msg3 and PUCCH for Msg4 for legacy UEs.   [vivo] While it is true theotically, we observed that the current commercial NR deployment in FR1 uses 20MHz initial DL and UL BWP, so practically no issue  We would like to capture additional issue regarding potential initial BWP congestion.   * eMBB and RedCap UEs may share the same initial BWP in DL and UL for initial access procedure, if the number of RedCap UEs in the network is large, there may be impact to eMBB UE performance in initial BWP due to congestion. |
| Samsung |  | We suggest the following change on last bullet:  Some of the initial DL/UL BWP configurations have a larger bandwidth than the bandwidth options considered for RedCap. This would have impact on Msg3 and PUCCH for Msg4 for RedCap UEs. If the network is restricted to use UL BWP configurations that have a bandwidth no greater than the RedCap UE bandwidth capability also for legacy UEs, there would be impacts on Msg3 and PUCCH for Msg4 for legacy UEs. Alternatively, Redcap UEs can be allowed to operate in BW wider than RF bandwith with some retuning time.  We are also OK with vivo’s suggestion. |
| NEC | Y |  |
| FL | Clarification: Note that the question concerns the TP right above the question, not the bullet lists above the TP. | |
| CATT | Y mostly | Suggest adding ‘Other UL channels before RRC setup’in the last bullet:  Some of the initial UL BWP configurations have a larger bandwidth than the bandwidth options considered for RedCap. This would have impact on Msg3, ~~and~~ PUCCH for Msg4 and other UL channels before RRC setup for RedCap UEs. If the network is restricted to use UL BWP configurations that have a bandwidth no greater than the RedCap UE bandwidth capability also for legacy UEs, there would be impacts on Msg3, ~~and~~ PUCCH for Msg4 and other UL channels before RRC setup for legacy UEs.  Regarding to Samsung’s comment, we think no need to add ‘DL/’, since initial DL BWP seems will not be larger than RedCap BW. |
| CMCC | Y | OK with CATT’s suggestion |
| DOCOMO | Y |  |
| LG | Y | As what we are discussing is the potential coexistence impacts, we are okay to include those additional issues in the TP even if there may be (partial) solutions in the end. In that sense, we also think the additional issue suggested by vivo needs to be captured. |
| ZTE | Y for first bullet | * Frequency-division multiplexed (FDM) RACH Occasions (RO) may have a total frequency span greater than the RedCap UE bandwidth. If RedCap UE and legacy UEs share the same ROs, this may result in restrictions in the configuration of FDM ROs, which have an impact on legacy UEs. * Some of the initial UL BWP configurations have a larger bandwidth than the bandwidth options considered for RedCap. If RedCap UE and legacy UEs share the same initial UL BWP, this would have impact on Msg3 and PUCCH for Msg4 for RedCap UEs. If the network is restricted to use UL BWP configurations that have a bandwidth no greater than the RedCap UE bandwidth capability also for legacy UEs, there would be impacts on Msg3 and PUCCH for Msg4 for legacy UEs. |
| SONY | Y | Typo:   * The 20-MHz bandwidth option for FR1 UEs allows a RedCap UE~~s~~ to reuse existing procedures for acquiring SSB, SIB1, other SIBs, RAR and Msg4. |
| FUTUREWEI4 | Y | OK to remove the additional issues |
| Qualcomm |  | We share the same view as Vivo for the last paragraph of the TP.  We are ok to remove the last paragraph starting with “The following additional issues have been identified as potential coexistence issues introduced by RedCap UE bandwidth reduction.” |
| Intel |  | Same view as Vivo and Qualcomm on the last paragraph (and bullets) of the TP. |

### 7.3.5 Analysis of specification impacts

The following potential specification impacts were identified in the contributions:

**General:**

* S1: (FR1) The specification impact is expected to be small in FR1 [11, 13, 21, 27],
* S2: (FR2) RAN1 specification impact is expected to be small for UE with 100 MHz bandwidth in FR2 [11].

**Initial access and initial BWP:**

* S3: (FR1) Rel-15 SSB and/or CORESET0 should be reused [12, 20].
* S4: (FR1) No spec impacts related to cell search, system information acquisition, RAR and Msg4 reception are expected for RedCap UEs [5].
* S5: (FR2) No spec impacts related to cell search, system information acquisition, RAR and Msg4 reception are expected for RedCap UEs with 100 MHz maximum UE bandwidth [5].
* S6: Support dedicated initial BWP or dedicated initial access procedure for RedCap [5, 7, 10, 12, 15, 16, 17, 24].
* S7: There is no need to define a dedicated initial BWP for RedCap UEs [1].
* S8: There are solutions that can be used to support RedCap UEs camping on a cell with initial DL or UL BWP bandwidth larger than the maximum UE bandwidth [1].
* S9: It is feasible to allow a RedCap UE to camp on a cell even when the initial DL or UL BWP configured in the cell is larger than the maximum UE bandwidth [1].
* S10: Support RF retuning for frequency-division multiplexed RACH Occasions or SSB/CORESET0 [1, 10, 24, 25].
* S11: During initial access procedure, if size of initial UL BWP configured for normal NR UEs is larger than the bandwidth of the RedCap UEs, Msg3 transmission of the RedCap UE can be flexibly scheduled and Msg3 hopping can be enabled if dedicated initial UL BWP is configured for the RedCap UEs [5].
* S12: For frequency-hopping Msg4 PUCCH or Msg3 PUSCH transmissions, the UE needs to frequency hop within the initial UL BWP, which may have a bandwidth larger than the maximum RedCap UE bandwidth [1].
* S13: Support configuring separated CD-SSB for RedCap UEs [17].

**Specification impact if dedicated initial BWP, dedicated initial access procedure, or dedicated BWP is introduced:**

* S14: Support initial BWP enhancement including at least one of following: multiple initial BWPs, enhancement on CORESET0, or narrow band Redcap UEs operate in a wide band system [15].
* S15: Using a separate DL BWP for SIB transmissions towards RedCap UEs [10].
* S16: Using a separate UL BWP for initial access of RedCap UEs (as well as common UL BWP shared with normal UEs) [10].
* S17: Initial BWP with non-CD SSB transmission dedicated for RedCap UEs [4].
* S18: Support dedicated BWP for RedCap [5, 7, 24].
* S19: UE switching to the dedicated BWP immediately after random access procedure may be considered to offload UEs from initial BWP [7, 26].
* S20: Mechanism for RedCap BWP switching (e.g., for switching UE from initial BWP to the dedicated BWP quickly or for other performance optimization considerations) [7, 26].
* S21: Introduce longer CORESET duration (Should be discussed in AI 8.6.3) [12, 24].
* S22: Introduce simplified BWP operation for RedCap [16].
* S23: Decouple the DL and UL BWP design for RedCap UE [16].
  + Support small DL bandwidth and large UL bandwidth.
  + Support fewer DL BWP configurations than that of UL.
* S24: Support SRS transmission or CSI report for inactive BWP(s) [15].

**System information:**

* S25: A new set of system information may be needed to indicate whether the cell supports RedCap UEs and to provide RRC configuration information [1].
* S26: System information that is needed for supporting RedCap UEs may be added as new information elements to existing SI blocks or as new SI blocks [1].
* S27: Support configuring separated resources for RedCap UEs in legacy SIB1 for RACH and paging [17].

**Paging:**

* S28: In Idle mode, dedicated paging occasions are considered for the RedCap UEs [5, 24].
* S29: The legacy paging procedure will work fine for RedCap UEs with 20 MHz bandwidth in FR1 and 50 MHz or 100 MHz bandwidth in FR2 [1].

**UE identification and capability signaling:**

* S30: Earlier identification of the RedCap UEs should be considered [5, 21].
  + S1: Identification of the RedCap UE before Msg3 transmission is needed if size of initial UL BWP configured for normal NR UEs is larger than the bandwidth of the RedCap UEs [5].
  + S1: The type of RedCap UE needs to be identified before RAR/Msg4 transmission [5].
* S31: Capability signaling defining that the UE supports a reduced bandwidth [4, 19, 21].

**RAN4:**

* S32: Most RF core requirements can be reused for supporting RedCap UE bandwidth reduction. However, certain modifications may be considered to reflect that the UE may not measure on the SSB at all times, if scheduled in other parts of the carrier [1].
* S33: There may be some minor performance impacts that need to be considered in RAN4 [19].

**Other aspects:**

* S34: In RRC\_CONNECTED, the RedCap UE can be scheduled within the maximum reception bandwidth even though the initial DL BWP configured for normal NR UEs is larger than the maximum UE bandwidth of RedCap UEs [5].
* S35: UE behavior, such as not expecting resource allocations exceeding the number of PRBs corresponding to BW limitation [2].
* S36: Support for RedCap UEs to be able to perform processing of the wider bandwidth PRS over a longer time period [19].
* S37: Study the maximum number BWPs for RedCap UEs [7].

**Additional specification impacts due to supporting 50 MHz UE in FR2:**

* S38: If the maximum UE bandwidth of RedCap UEs is 50 MHz, to guarantee the performance of RedCap UEs, dedicated common CORESET may need to be configured for system information acquisition, RAR and Msg4 reception [5].
* S39: Specification impact for reading system information [3]
* S40: Define a separate CORESET0 for RedCap UEs [27].
* S41: To allow the 240 kHz SCS SSB configuration to be used UEs with 50 MHz maximum bandwidth, the minimum guardband for SSB reception needs to be specified [1].
* S42: UE performance requirements may have to be defined for both SSB and CORESET0 in case of 50 MHz UE [11].
* S43: Enhancements are needed to compensate for potential PDCCH coverage reduction if FR2 50MHz maximum UE bandwidth is supported for initial access [9].
* S44: Reducing the UE RF bandwidth to 50MHz in FR2 may have significant specification for SSB/CORESET0 configurations using 240 kHz SCS [11, 21].
  + Potential solutions needed to address this issue require specification work
    - S45: Cell barring for the RedCap UEs. For example, the above-mentioned bandwidth is larger than the supportable maximum bandwidth of the RedCap UEs [21].
    - S46: Allowing to omit reception of channel/signal outside of its supportable maximum bandwidth, and so on [21].
    - S47: Additional or separate DL BWPs for RedCap UEs at least for some, if not all, common control [8].
    - S48: Some limitations or modifications may also need to be captured for FR2 50MHz e.g for multiplexing or retuning [2].

The FL understanding is that some potential specification impacts (S21, S30, S31, S43, S45) can be addressed in the TR sections related to other AIs, more specifically:

* S21, S43 🡪 AI 8.6.3
* S30, S31, S45 🡪 AI 8.6.4 & AI 8.6.5

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| All the UE bandwidth reduction options considered are expected to have small specification impacts. There is no need for introducing a new SSB, CORESET#0, initial access procedure, random-access procedure, paging, etc. With proper configurations of RRC parameters, the network may be able to support RedCap UE bandwidth reduction with minor or no additional specification changes.  However, to address the performance and coexistence impacts identified in subcluses 7.3.3 and 7.3.4, specification work would be needed. |

**FL3: Phase 3: Question 7.3.5-2: Can the above observations of specification impacts of UE bandwidth reduction be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| FL | Clarification: Note that the question concerns the TP right above the question, not the bullet lists above the TP. | |
| CATT | Y mostly | Seems ‘initial access procedure’ and ‘random-access procedure’ are the similar meaning. Does it mean: ‘~~initial access~~cell search procedure’? |
| CMCC | Y |  |
| DOCOMO | Y |  |
| ZTE |  | All the UE bandwidth reduction options considered are expected to have small specification impacts. With proper configurations of RRC parameters, the network may be able to support RedCap UE bandwidth reduction with minor or no additional specification changes. |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| FUTUREWEI4 | N | Suggest to say at least for 20MHz in FR1 and 100MHz in FR2, as there were a number of conerns raised for FR2 50MHz. |
| Qualcomm | Y mostly | We suggest to add the following sentence to the TP:  With proper configurations of RRC parameters and support of early indication of RedCap UE type, the network may be able to support RedCap UE bandwidth reduction with minor or no additional specification changes |
| Intel | Y |  |

## 7.4 Half-duplex FDD operation

### 7.4.1 Description of feature

RAN1#103e agreement:

* Adopt the TP in [R1-2009393](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009393.zip) as baseline text for TR clause 7.4.1.

### 7.4.2 Analysis of UE complexity reduction

RAN1#103e agreements:

* Adopt the TP in Proposal 7.4.2-1e in R1-2009651 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/R1-2009651.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009651.zip)) as baseline text for TR clause 7.4.2.
* Adopt the description in Proposal 7.4.2-2 in R1-2009651 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/R1-2009651.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009651.zip)) of the benefit of HD-FDD operation in terms of reducing the device size in FR1 FDD as a baseline text for TR 38.875.

### 7.4.3 Analysis of performance impacts

RAN1#103e agreement:

* TPs corresponding to Questions 7.4.3-2a/3a/6/7a in R1-2009651 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/R1-2009651.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009651.zip)).

**Data rate:**

* P1: HD-FDD reduces data rate compared to FD-FDD [2, 3, 4, 6, 19, 24].
* P2: HD-FDD Redcap UEs can fulfil all the RedCap data rate requirements [1, 5, 22].
* P3: Type A HD-FDD has minor data rate and latency degradation [18].
* P4: Type B HD-FDD has a significant impact on the throughput and/or latency performance [6, 18].
* P5: It might be problematic for HD-FDD UEs to fulfill the data rate requirements of high-end wearables (e.g. 50/150 Mbps peak bitrate in UL/DL) without relying on high modulation order, MIMO and/or carrier aggregation capability [28].

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| **Data rate:**  There is minor impact from HD-FDD operation on instantaneous data rates for uplink or downlink, but HD-FDD reduces user throughput compared to FD-FDD, especially in case of simultaneous downlink and uplink traffic. |

**Phase 2: Question 7.4.3-4: Can the above observations of the impact on data rate for HD-FDD operation be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| ZTE | Y |  |
| vivo |  | HD-FDD reduces data rate compared to FD-FDD, but the peak data rate requirements of some RedCap use cases can still be fulfilled. |
| SONY5 | Y |  |
| Qualcomm | Y |  |
| DOCOMO | Y |  |
| Sierra Wireless | Y |  |
| Samsung | Y |  |
| Ericsson | Y | Perhaps it can be clarified in the text that the statement concerns the individual technique, not combinations with other techniques. |
| Intel | Y |  |
| CATT | Y, partially | Better to add ‘most of’ or ‘some’ before the ‘RedCap use cases’. If the use case requires both DL and UL data rate at the same time (e.g. real time video interaction), it is possible that the data rate requirement can not be fulfilled. |
| LG | Y | Also fine with the clarification from vivo, and Ericsson. |
| Huawei, HiSilicon | N | We are not sure about the observation. It will depend on the UL:DL ratio and the peak data rate may only be satisfied in either DL or UL but not both. |
| FL | The proposal has been updated based on received responses.  **FL2: Phase 2: Question 7.4.3-4a: Can the above observations of the impact on data rate for HD-FDD operation be used as a baseline text for TR 38.875?** | |
| CATT | Y |  |
| Qualcomm | Y |  |
| ZTE | Y | But we prefer the original TP. |
| Samsung |  | We suggest to add the following if changing data rate to User throughput.  There is minor impact on instant data rate for uplink or downlink. |
| Huawei, HiSilion | Y but | Is it user throughput or data rate? |
| FUTUREWEI3 | Y |  |
| Ericsson | Y |  |
| SONY7 | Y |  |
| Intel | Y |  |
| FL | The proposal has been updated based on received responses.  **FL3: Phase 2: Question 7.4.3-4b: Can the above observations of the impact on data rate for HD-FDD operation be used as a baseline text for TR 38.875?** | |
| Ericsson | Y |  |
| vivo | Y |  |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| Xiaomi | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| Qualcomm | Y |  |
| MediaTek | Y |  |
| Intel | Y |  |
| Sierra Wireless | Y |  |

**Latency and reliability:**

* P8: HD-FDD introduces longer latency than FD-HDD [3, 6, 19, 24, 28].
* P9: An HD-FDD UE in RRC\_CONNECTED can meet the 5-10 ms latency requirement for safety related sensors [1, 4].
* P10: HD-FDD has less impact on latency compared to TDD [19].
* P11: The latency requirement can be met if NR dynamic TDD is reused for HD-FDD [5].
* P12 The safety sensor use case has strict latency requirements of 5-10 ms which seems difficult for an HD-FDD device to meet [28].

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| **Latency and reliability:**  HD-FDD introduces longer latency than FD-HDD, especially in case of simultaneous downlink and uplink traffic, but the latency and reliability requirements of RedCap use cases can still be fulfilled for most of the RedCap use cases. |

**Phase 2: Question 7.4.3-5: Can the above observations of the impact on latency and reliability for HD-FDD operation be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| ZTE | Y |  |
| vivo |  | HD-FDD introduces longer latency than FD-HDD, but the latency and reliability requirements of most of RedCap use cases can still be fulfilled. |
| SONY5 | Y |  |
| Qualcomm | Y |  |
| DOCOMO | Y |  |
| Sierra Wireless | Y |  |
| Samsung | Y |  |
| Ericsson | Y |  |
| Intel | Y |  |
| OPPO |  | Share similar view with vivo |
| CATT | Y, partially | Similar to vivo. Better to add ‘most of’ or ‘some’ before the ‘RedCap use cases’. |
| LG | Y | Also fine with the modification from vivo. |
| Huawei, HiSilicon | N | HD-FDD introduces longer latency than FD-HDD, but the latency and reliability requirements of RedCap use cases can still be fulfilled at least in one way (i.e. either UL or DL) depending on gNB scheduling and Rx-Tx swictching time capability, HARQ retransmission times. |
| FL | The proposal has been updated based on received responses.  **FL2: Phase 2: Question 7.4.3-5a: Can the above observations of the impact on latency and reliability for HD-FDD operation be used as a baseline text for TR 38.875?** | |
| CATT | Y |  |
| Qualcomm | Y |  |
| ZTE | Y | But we prefer the original TP. |
| Samsung | Y |  |
| Huawei, HiSilion | Y |  |
| LG | N | Not sure if we need to separate DL and UL latency and also not sure if there are separate requirements for DL and UL. We would like to keep it simple as follows:  HD-FDD introduces longer latency than FD-HDD, especially in case of simultaneous downlink and uplink traffic, but the latency and reliability requirements of RedCap use cases can still be fulfilled for most of the RedCap use cases. |
| FUTUREWEI3 | Y |  |
| Ericsson | Y |  |
| SONY7 | Y | OK, but prefer original TP. |
| Intel | N | Prefer the version from LG or the original version. |
| FL | The proposal has been updated based on received responses.  **FL3: Phase 2: Question 7.4.3-5b: Can the above observations of the impact on latency and reliability for HD-FDD operation be used as a baseline text for TR 38.875?** | |
| Ericsson | Y |  |
| vivo | Y |  |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| Qualcomm | Y |  |
| MediaTek | Y |  |
| Intel | Y |  |
| Sierra Wireless | Y |  |

### 7.4.4 Analysis of coexistence with legacy UEs

The following potential coexistence impacts were identified in the contributions:

* C1: Introducing HD-FDD operation will make gNB scheduling more complicated [2, 10, 24].
* C2: HD-FDD may introduce scheduling constraints to URLLC services and may introduce issues with pre-emption indicator monitoring [3, 19, 28].
* C3: Introducing HD-FDD operation has no impact on initial access procedure as it is not likely to require simultaneous uplink and downlink transmission in legacy implementations during initial access [1, 11, 19].
* C4: Potential impact on RACH procedure to support Type B HD-FDD UE can be expected, e.g., switching time from PRACH to Msg2 for Type B HD-FDD [15, 24].
* C5: Introducing the support of Type-A HD-FDD operation will not introduce any coexistence issues with legacy UEs [1, 5].
* C6: Introducing the support of Type B HD-FDD operation may require longer time gaps between subsequent messages in the random-access procedure and may therefore introduce longer delay in the random-access procedure for legacy UEs [1].
* C7: Introducing Type B HD-FDD operation has a significant impact on the gNB scheduler [1].
* C8: HD-FDD introduces limitation on the configuration of some common RS/channels for both legacy and RedCap UEs [3].
* C9: Scheduling effectiveness is not compromised by supporting Type-A HD-FDD UE’s in paired spectrum, since each UE could switch between DL and UL at independent points in time, according to their respective scheduled or configured uplink transmissions [23].
* C10: With Type A HD FDD, only the duplexer is dropped, and the same (full-duplex) UE modem can be reused in full-duplex and half-duplex FDD UE designs, thus avoiding UE modem market fragmentation [23].

This potential impact has been moved here from Section 7.4.3 of this document where it was known as P21:

* C11: BWP adaptation may have an impact on HD-FDD operation. [7].

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| Introducing HD-FDD operation will make gNB scheduling more complicated. The impact due to the support for HD-FDD Type B operation is greater than for Type A.  For initial access, supporting HD-FDD Type B operation might have a potential impact on the RACH procedure in that longer time gaps between messages might be needed. One example is the switching time from PRACH to Msg2. Supporting HD-FDD Type B operation could require that a longer switching time from PRACH to Msg2 is used for all UEs, if the RedCap UEs are not identified in Msg1. This is not an issue for Type A due to its faster UL-to-DL switching capability. |

**FL3: Phase 3: Question 7.4.4-2: Can the above observations of coexistence impacts of HD-FDD be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| Samsung |  | We sugget the following change:  Introducing HD-FDD operation ~~will~~ might make gNB scheduling more complicated. The impact due to the support for HD-FDD Type B operation is greater than for Type A.  For initial access, supporting HD-FDD Type B operation might have a potential impact on the RACH procedure in that longer time gaps between messages might be needed. One example is the switching time from PRACH to Msg2. Supporting HD-FDD Type B operation could require that a longer switching time from PRACH to Msg2 is used for all UEs, if the RedCap UEs are not identified in Msg1. This is not an issue for Type A due to its faster UL-to-DL switching capability. |
| FL | Clarification: Note that the question concerns the TP right above the question, not the bullet lists above the TP. | |
| CATT | Y | Fine with the current version. |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y | Also okay with the change suggested by Samsung. |
| ZTE |  | For initial access, supporting HD-FDD Type B operation might have a potential impact on the RACH procedure in that longer time gaps between messages might be needed. One example is the switching time from PRACH to Msg2. Supporting HD-FDD Type B operation may cause that a longer switching time from PRACH to Msg2 is used for all UEs, if the RedCap UEs are not identified in Msg1. This is not an issue for Type A due to its faster UL-to-DL switching capability. |
| Nokia, NSB | Y |  |
| SONY | Y as baseline | We think that something needs to be added about the impact on URLLC. This seems like more of a coexistence issue than some others (if the coverage is a little worse for some techniques, then the scheduler can assign a lower MCS to allow for “coexistence”, but if an HD-FDD UE cannot read a cancellation indicator, then URLLC can not be scheduled in resources overlapping an UL transmission from an HD-FDD Redcap UE).  So we think that something about C2 needs mentioning. The more important aspect of C2 (in our view) is UL cancellation indication, rather than DL pre-emption indication. Not being able to read a DL pre-emption indicator would cause some performance loss to the HD-FDD Redcap UE whereas not being able to read the UL cancellation indicator (a DL signal) would cause collision between Redcap and URLLC transmissions. We propose the following additional text:  HD-FDD operation would impact coexistence with URLLC services when the Redcap UE is transmitting in the UL and hence not able to monitor the DL pre-emption indicator or UL cancellation indicator. |
| Qualcomm |  | Agree with the suggestion of Samsung |
| Intel |  | Support the suggestion from Samsung. |
| Sierra Wireless |  | Support the suggestion from Samsung. |

### 7.4.5 Analysis of specification impacts

The following potential specification impacts were identified in the contributions:

* S1: RAN1 specification impact is expected to be minor [11, 17].
* S2: RAN1 specification impact is expected to be small for supporting Type A HD-FDD [1, 21].
* S3: Introducing Type B HD-FDD operation would have much more specification impacts than Type A [1].
* S4: Need to specify DL-to-UL and UL-to-DL switching time [1, 3, 4, 5, 6, 8, 12, 13, 19, 21, 22, 24].
* S5: RAN4 should decide on switching time requirements during the work item phase [19].
* S6: Need to specify HD-FDD capability signaling [1, 4, 5, 19, 21].
* S7: Need to specify how to handle DL/UL collision [1, 4, 8, 24].
* S8: For Type A HD-FDD, the guard period for DL-to-UL and UL-to-DL switching may be relaxed compared to the minimum Rx-to-Tx and Tx-to-Rx switching times defined in Rel-15 for a UE not supporting full-duplex communication [8].
* S9: The DL-to-UL and UL-to-DL switching time for a Type A HD-FDD device can reuse the same values of and specified in Table 4.3.2-3 of TS 38.211 [1].
* S10: The values of and specified in Table 4.3.2-3 of TS 38.211 cannot be used as DL-to-UL and UL-to-DL switching time for a Type B HD-FDD device [1].
* S11: Need to define applicable bands and performance requirements for HD-FDD operation [4].
* S12: RAN4 specification changes such as new reference sensitivity, RRM, and performance requirements can be expected, due to the lack of a duplexer, thus less insertion loss [1].
* S13: Thanks to the flexibility in the TDRA and HARQ timing in NR, there is less motivation to adopt features such as increasing the number of HARQ processes, multi-TB scheduling, and HARQ-ACK bundling, if Type A HD-FDD is introduced for RedCap [1].
* S14: If for unforeseeable reasons, features such as increasing the number of HARQ processes, multi-TB scheduling, and HARQ-ACK bundling, need to be introduced for enhancing the throughput for an HD-FDD UE, the specification impacts will be very significant [1].
* S15: Need to specify how DL pre-emption and UL cancellation work when HD-FDD UEs share resources with URLLC UEs [19].
* S16: Need to specify how to prioritize between eMBB traffic and URLLC traffic for the cases of (1) eMBB DL and URLLC UL and (2) eMBB UL and URLLC DL [19].
* S17: The gNB should be able to configure DL or UL durations for HD-FDD UE [12].
* S18: Type A HD-FDD operation will not impact BWP switch delay requirements [1].
* S19: Type B HD-FDD operation will require defining new BWP switch delay requirements [1].
* S20: RedCap UEs in HD-FDD mode should support BWP switching for power saving [7].

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| Introducing support for HD-FDD operation is expected to have the following impacts on RAN1 specifications.   * Specifying DL-to-UL and UL-to-DL switching time * Specifying how the UE handles DL/UL collision   Additionally, HD-FDD support also has the following impacts on RAN4 specifications.   * Specifying applicable bands * Specifying performance requirements such as reference sensitivity and RRM |

**FL3: Phase 3: Question 7.4.5-2: Can the above observations of coexistence impacts of HD-FDD be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| vivo |  | We are wondering if the listed RAN1 spec impact is really needed. In our understanding, the following text in 38.211 section 4.3.2 for half-duplex UEs are applicable to HD-FDD operations.  A UE not capable of full-duplex communication and not supporting simultaneous transmission and reception as defined by parameter *simultaneousRxTxInterBandENDC, simultaneousRxTxInterBandCA or simultaneousRxTxSUL* [10, TS 38.306] among all cells within a group of cells is not expected to transmit in the uplink in one cell within the group of cells earlier than after the end of the last received downlink symbol in the same or different cell within the group of cells where is given by Table 4.3.2-3.  A UE not capable of full-duplex communication and not supporting simultaneous transmission and reception as defined by parameter *simultaneousRxTxInterBandENDC*, *simultaneousRxTxInterBandCA* *or simultaneousRxTxSUL* [10, TS 38.306] among all cells within a group of cells is not expected to receive in the downlink in one cell within the group of cells earlier than after the end of the last transmitted uplink symbol in the same or different cell within the group of cells where is given by Table 4.3.2-3.  A UE not capable of full-duplex communication is not expected to transmit in the uplink earlier than after the end of the last received downlink symbol in the same cell where is given by Table 4.3.2-3.  A UE not capable of full-duplex communication is not expected to receive in the downlink earlier than after the end of the last transmitted uplink symbol in the same cell where is given by Table 4.3.2-3.  Table 4.3.2-1: Number of OFDM symbols per slot, slots per frame, and slots per subframe for normal cyclic prefix.   |  |  |  |  | | --- | --- | --- | --- | |  |  |  |  | | 0 | 14 | 10 | 1 | | 1 | 14 | 20 | 2 | | 2 | 14 | 40 | 4 | | 3 | 14 | 80 | 8 | | 4 | 14 | 160 | 16 |   Table 4.3.2-2: Number of OFDM symbols per slot, slots per frame, and slots per subframe for extended cyclic prefix.   |  |  |  |  | | --- | --- | --- | --- | |  |  |  |  | | 2 | 12 | 40 | 4 |   Table 4.3.2-3: Transition time and   |  |  |  | | --- | --- | --- | | **Transition time** | **FR1** | **FR2** | |  | 25600 | 13792 | |  | 25600 | 13792 | |
| FL | Clarification: Note that the question concerns the TP right above the question, not the bullet lists above the TP. | |
| CATT | Y, mostly | Currently, DL-to-UL and UL-to-DL switching time have been defined in TS 38.211, Table 4.3.2-3 (though for normal NR UE which is not capable of full-duplex communication). If they can be reused to RedCap UE, seems no additional RAN1 specification is required. If not, there may be specnfication impacts. Similar to the collision handling.  We suggest:  Introducing support for HD-FDD operation ~~is expected to~~may have the following impacts on RAN1 specifications. |
| CMCC | Y |  |
| DOCOMO | Y | Also fine with CATT’s modification |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y | We assume that “Specifying how the UE handles DL/UL collision” covers both the intra-UE and inter-UE cases (e.g. the URLLC collision case discussed in question 7.4.4-2). |
| FUTUREWEI4 | Not quite | The analysis of impacts showed differences in type A and type B, somehow the different level of impact should be reflected. This could also be related to Vivo’s comment. |
| Qualcomm |  | Agree with the suggestion of CATT |
| Intel | N | Agree with Vivo, but could accept the modification from CATT for sake of progress. |
| Sierra Wireless | Y |  |

## 7.5 Relaxed UE processing time

### 7.5.1 Description of feature

RAN1#103e agreements:

* Adopt the TP in Proposal 7.5.1-3 in R1-2009651 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/R1-2009651.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009651.zip)) as baseline text regarding relaxed CSI computation, either in TR clause 7.5.1 or in a TR (sub)clause on relaxed CSI computation.
* Adopt the TP in Proposal 7.5.2-1e in R1-2009651 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/R1-2009651.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009651.zip)) as baseline text for TR clause 7.5.2.

### 7.5.2 Analysis of UE complexity reduction

RAN1#103e agreement:

* Adopt the TP in Proposal 7.5.2-1e in R1-2009651 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/R1-2009651.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009651.zip)) as baseline text for TR clause 7.5.2.

### 7.5.3 Analysis of performance impacts

RAN1#103e agreement:

* TP corresponding to Question 7.5.3-3a in R1-2009651 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/R1-2009651.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009651.zip)).

**Coverage:**

* P6: Contributions [1, 2, 4, 11, 15, 24] note that no significant coverage impact is expected from a more relaxed UE processing time.

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| **Coverage:**  No coverage impact is expected from a more relaxed UE processing time. |

**Phase 2: Question 7.5.3-2: Can the above observations of the impact on coverage for UE with relaxed UE processing time be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| ZTE | Y |  |
| vivo | Y |  |
| SONY5 | Y |  |
| FUTUREWEI | Y |  |
| DOCOMO | Y |  |
| Sierra Wireless | Y |  |
| Samsung | Y |  |
| Ericsson | Y |  |
| Intel | Y |  |
| Spreadtrum | Y |  |
| OPPO | Y |  |
| CATT | Y |  |
| LG | Y |  |
| Huawei, HiSilicon | Y with modificatioins | Please remove “significant”. This can be obvious similar to that no coverage loss comparing Cap#1 with Cap#2. |
| Nokia, NSB | Y |  |
| FL | The proposal has been updated based on received responses.  **FL2: Phase 2: Question 7.5.3-2a: Can the above observations of the impact on coverage for UE with relaxed UE processing time be used as a baseline text for TR 38.875?** | |
| Ericsson | Y | The ‘Phase 2’ tag was missing in this updated question. We have inserted the missing tag now, but it seems that many companies may have missed the updated question. |
| SONY7 | Y |  |
| Intel | Y |  |
| FL | The proposal is unchanged. Because of a missing tag (‘Phase 2’), this proposal did not receive enough attention in the previous discussion round.  **FL3: Phase 2: Question 7.5.3-2a: Can the above observations of the impact on coverage for UE with relaxed UE processing time be used as a baseline text for TR 38.875?** | |
| Ericsson | Y |  |
| vivo | Y |  |
| NEC | Y |  |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| MediaTek | Y |  |
| Intel | Y |  |

**Data rate:**

* P5: Contributions [1, 2, 15, 24, 26] mention that sustained data rate may be impacted due to longer HARQ RTT because of the relaxed UE processing time.

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| **Data rate:**  No impact on peak data rate is expected. |

**Phase 2: Question 7.5.3-4: Can the above observations of the impact on data rate for UE with relaxed UE processing time be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| ZTE | Y |  |
| SONY5 | Partially Y | Presumably, the second sentence assumes that there is no increase in the number of HARQ processes (which is probably a reasonable assumption) |
| FUTUREWEI | Y |  |
| DOCOMO | Y |  |
| Samsung | Y |  |
| Ericsson | Y | Perhaps it can be clarified in the text that the statement concerns the individual technique, not combinations with other techniques. |
| Intel | N | We do not think that, with 16 HARQ processes, there will be an adverse impact to achievable sustained data rate in all FDD and most typical TDD configurations. Certainly, there can be extreme TDD configurations where there could be an impact, but these may be rather atypical. Thus, prefer to remove the second sentence. |
| OPPO | Partially Y | We are wondering whether there is date rate impact with 16 HARQ processes. |
| CATT | Y |  |
| Huawei, HiSilicon | Y |  |
| FL | The proposal has been updated based on received responses.  **FL2: Phase 2: Question 7.5.3-4a: Can the above observations of the impact on data rate for UE with relaxed UE processing time be used as a baseline text for TR 38.875?** | |
| vivo |  | The 2nd sentence after adding “It is unclear whether” is confusing to readers, suggest to delete the whole sentence if it is not sure yet. |
| Ericsson | Y | The ‘Phase 2’ tag was missing in this updated question. We have inserted the missing tag now, but it seems that many companies may have missed the updated question. |
| SONY7 | Y | Would also be OK to delete the second sentence. |
| Intel | N | Similar to Vivo, prefer to delete the second sentence. |
| FL | The proposal has been updated based on received responses. Because of a missing tag (‘Phase 2’), this proposal did not receive enough attention in the previous discussion round.  **FL3: Phase 2: Question 7.5.3-4b: Can the above observations of the impact on data rate for UE with relaxed UE processing time be used as a baseline text for TR 38.875?** | |
| Ericsson | Y |  |
| vivo | Y |  |
| Samsung |  | It is not true if we considering RTT time. Therefore, we sugges to add:  No impact on instant peak data rate is expected without considering HARQ around trip time. |
| NEC | Y |  |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| Qualcomm | N | Agree with the suggestion of Samsung in general. Alternatively, we suggest the following changes:  *No impact on instantaneous peak data rate is expected, but reduced UE throughput is expected due to extended HARQ around trip time.* |
| MediaTek | N | We tend to agree with Samsung’s modification. |
| Intel | Y | To those saying “No”, the point is about whether there would be an impact considering the data rate targets and use-cases we are considering for RedCap UEs – that is what matters in context of current study. |

**Latency and reliability:**

* P1: Contributions [1, 4, 5, 6, 9, 13, 16, 23, 24, 26, 28] mentioned the impact of relaxed UE processing time capability on latency, where [1, 4, 5, 23] provide some numerical examples of the impact on UL and DL latency for the initial transmission and different number of retransmissions.
* P2: Contributions [1, 3, 4, 5, 16, 21, 23, 24] observe that many RedCap use cases have rather relaxed latency requirements of up to 100 ms or 500 ms and thus can afford to have more relaxed UE processing time if the trade-off between cost reduction benefits and impacts is justified.
* P3: It is mentioned in several contributions [1, 2, 5, 6, 13, 23, 24, 26, 28] that for some use cases such as safety-related sensors, rather strict latency may be required, and a more relaxed UE processing may not be feasible.

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| **Latency and reliability:**  Relaxed UE processing time in terms of N1/N2 has impact on latency. For downlink transmission, relaxed N1 value impacts how fast HARQ-ACK feedback can be sent after the reception of PDSCH. For uplink transmission, relaxed N2 value impacts how fast PUSCH can be scheduled with respect to the UL grant. How significant the impact on latency is depends on use cases and scheduled number of retransmissions. |

**Phase 2: Question 7.5.3-5: Can the above observations of the impact on latency and reliability for UE with relaxed UE processing time be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| ZTE | Y |  |
| SONY5 | Y |  |
| Qualcomm |  | We agree with most part of the proposal, and suggest to remove the last sentence as follows:  Relaxed UE processing time in terms of N1/N2 has impact on latency. For downlink transmission, relaxed N1 value impacts how fast HARQ-ACK feedback can be sent after the reception of PDSCH. For uplink transmission, relaxed N2 value impacts how fast PUSCH can be scheduled with respect to the UL grant. How significant the impact on latency is depends on use cases and targeted number of retransmissions. Among the RedCap use cases, some safety-related sensor use cases may have rather strict latency requirements, for which relaxed UE processing time may not be feasible. For the other RedCap use cases, the latency requirements can be fulfilled. |
| DOCOMO | Y |  |
| Sierra Wireless | Y |  |
| Samsung | Y |  |
| Ericsson | Y |  |
| Intel | N | We suggest removing this sentence:  “Among the RedCap use cases, some safety-related sensor use cases may have rather strict latency requirements, for which relaxed UE processing time may not be feasible.”  We do not agree that it is not feasible to achieve 5-10 ms latency performance with doubling of N1/N2 values from Cap #1 numbers for low throughput data as identified for IWSN (even targeting 99.99% reliability). In fact, it should also be possible to accommodate reTx as well, except possibly some particular TDD configurations (and one can find such even for NR). Note that, for latency estimates, the NW component of the latency could still be assumed to operate at Cap #1 equivalent (i.e., need not be assumed to be relaxed as well). |
| OPPO |  | Agree with intel. |
| CATT | Y |  |
| Huawei, HiSilicon | N | The observation needs modifications. Given certain TDD configuration and specific deployment scenairos, it is still with large possibility that doubled processing time can meet the latency requirement even for safety related sensors, just with less retransmission times. The latency due to more HARQ retransmissions also hold for other techniques, e,g. HD-FDD. Suggest to  Relaxed UE processing time in terms of N1/N2 has impact on latency. For downlink transmission, relaxed N1 value impacts how fast HARQ-ACK feedback can be sent after the reception of PDSCH. For uplink transmission, relaxed N2 value impacts how fast PUSCH can be scheduled with respect to the UL grant. How significant the impact on latency ~~is~~ depends on use cases and ~~targeted~~ scheduled number of retransmissions. Among the RedCap use cases, some safety-related sensor use cases may have rather strict latency requirements, for which there may be less HARQ retramissions performed with relaxed UE processing time ~~ay not be feasible~~. For the other RedCap use cases, the latency requirements can be fulfilled. |
| FL | The proposal has been updated based on received responses.  **FL2: Phase 2: Question 7.5.3-5a: Can the above observations of the impact on latency and reliability for UE with relaxed UE processing time be used as a baseline text for TR 38.875?** | |
| CATT | Y |  |
| Qualcomm | N | We can agree with this proposal if the last sentence is removed, i.e.  For the other RedCap use cases, the latency requirements can be fulfilled. |
| ZTE | Y |  |
| Huawei, HiSilion | Y with modificiation | Typo: “latency is depends”. Not sure about QC concern on the last.  “for which relaxed UE processing time may not be feasible at least for some TDD configurations depending on the possible number of HARQ retransmissions within the latency requirement” |
| Spreadtrum | Y |  |
| LG |  | It would be okay to us if the last two senstences (starting from Among …) are removed. |
| FUTUREWEI3 | Y |  |
| Ericsson | Y |  |
| SONY7 | Y | The “is” in “latency is depends” should be there (or something like “The significance of the impact on latency depends…”). We are OK with the text as is, as we probably don’t want to deal with an updated proposal. |
| Intel | N | Huawei’s original recommendation is most accurate. However, can also accept the modified version from Huawei in this round of comments, but agree with SONY that the “is” in “latency is depends” should be there. 😊 |
| FL | The proposal has been updated based on received responses.  **FL3: Phase 2: Question 7.5.3-5b: Can the above observations of the impact on latency and reliability for UE with relaxed UE processing time be used as a baseline text for TR 38.875?** | |
| Ericsson | Y |  |
| vivo | Y |  |
| NEC | Y |  |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| Qualcomm | Y |  |
| MediaTek | N | We don’t agree on removing this part “*Among the RedCap use cases, some safety-related sensor use cases may have rather strict latency requirements, for which relaxed UE processing time may not be feasible at least for some TDD configurations*.”  To achieve such small latency (5ms) with high reliability, several retransmissions are needed to operate with good spectral efficiency. Otherwise, the gNB will have to rely on single-shot transmissions which is will have significant impact on the system performance given the required high reliability. This issue will be more problematic for RedCap UEs because of the reduced diversity gain (due to #Rx reduction).  It is worth mentioning that the use-case specific requirements in the SID has highlighted such low latency requirements “*For safety related sensors, latency requirement is lower, 5-10 ms (TR 22.804)*”. Thus, this requirement shouldn’t be deprioritized. |
| Intel | Y | We do not agree with the comment from MediaTek that, for small packets and low data rates, to achieve 5 – 10 ms latency and high reliability, many retransmissions are needed. In fact, for most configurations, with this time-budget, at least one if not multiple reTx can be accommodated even with doubled N1/N2. |

**Power consumption:**

* P8: Contributions [3, 5, 13, 16] mention that relaxed processing timeline can allow for lower clock frequency and lower voltage which has an impact on the UE power consumption.
* P9: Contributions [4, 16] mentioned that power saving benefit from cross-slot scheduling can be obtained from relaxed UE processing time.
* P10: Contributions [5, 6, 11, 24, 26, 28] noted that the UE power saving gain may not be clear or may even be degraded as UE may need to stay active longer due to more relaxed UE processing time, and that it may also depend on specific implementation.
* P11: Contribution [1] notes that the NW can configure RedCap UEs to achieve power saving gain from cross-slot scheduling even if no relaxed UE processing time capability is defined.

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| **Power consumption:**  Relaxed UE processing time in terms of N1/N2 may allow for processing with lower clock frequency and lower voltage which helps reducing the UE power consumption. The impact on power consumption of relaxed UE processing time depends on implementation and traffic characteristics. |

**Phase 2: Question 7.5.3-6: Can the above observations of the impact on power consumption for UE with relaxed UE processing time be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| ZTE | Partially Y | The last sentence should be “The impact on power consumption of relaxed UE processing time depends on implementation and traffic characteristics.” |
| vivo |  | We are not sure if the 2nd sentence is true and propose to delete it. One simple example, do we expect a Cap#1 NR UE will be more power consuming than a Cap#2 NR UE?  Relaxed UE processing time in terms of N1/N2 may allow for processing with lower clock frequency and lower voltage which has an impact on the UE power consumption. ~~However, on the other hand, relaxed UE processing time may have a negative impact on UE average power consumption because the UE will be active for a longer time before being able to return to a lower power light sleep or deep sleep state.~~ The impact on power consumption of HD-FDD depends on implementation and traffic characteristics. |
| SONY5 | Y | Agree with ZTE. OK with all the sentences. |
| Qualcomm | Y |  |
| DOCOMO | Y |  |
| Sierra Wireless | Y | Agree with ZTE correction. |
| Samsung | Y |  |
| Ericsson | Y | Fine assuming the typo pointed out by ZTE is fixed |
| Intel | N | Agree with Vivo that the second sentence should be removed since it is not necessarily true. It is not necessarily the case that the UE can transition to lower power states with Cap #1 vs. doubling the Cap #1 numbers, and when considering support of multiple HARQ processes.  ~~However, on the other hand, relaxed UE processing time may have a negative impact on UE average power consumption because the UE will be active for a longer time before being able to return to a lower power light sleep or deep sleep state.~~ |
| OPPO |  | Agree with vivo and intel |
| CATT | Y |  |
| Huawei, HiSilicon |  | Share the view with vivo. As replied in FL4, the power comsumption benefits due to low voltage is exponential contribution, which would be larger on the negative impact due to longer active time. |
| FL | The proposal has been updated based on received responses.  **FL2: Phase 2: Question 7.5.3-6a: Can the above observations of the impact on power consumption for UE with relaxed UE processing time be used as a baseline text for TR 38.875?** | |
| CATT | Y | Fine to keep it simple. |
| Qualcomm | Y |  |
| ZTE | Y |  |
| Huawei, HiSilicon | Y |  |
| Spreadtrum | Y |  |
| LG | Y | We are okay with this proposal, but we prefer the following wording as the word “impact” feels just neutral.  Relaxed UE processing time in terms of N1/N2 may allow for processing with lower clock frequency and lower voltage which helps reducing the UE power consumption |
| FUTUREWEI3 | Y | OK with LGE update |
| Ericsson | Y |  |
| SONY7 | Y |  |
| Intel | Y with modification | As suggested by LG. |
| FL | The proposal has been updated based on received responses.  **FL3: Phase 2: Question 7.5.3-6b: Can the above observations of the impact on power consumption for UE with relaxed UE processing time be used as a baseline text for TR 38.875?** | |
| Ericsson | Y |  |
| vivo | Y |  |
| NEC | Y |  |
| CATT | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y | This (below) sounds better to me, but we are OK with the original if changing is a hassle.  and lower voltage which helps reduc~~inge~~ the UE power consumption |
| Qualcomm | Y |  |
| MediaTek | N | We disagree with this statement.  First of all, if the UE takes longer to decode the PDCCH (by making use of the relaxed N1/N2), it will have to keep its RF on for longer in case there is PDSCH scheduled.  Even if a reduced clock rate could reduce the peak power dissipation, it is not clear how much it would reduce the average power because at a lower clock rate, the chip would need to operate for a longer time and the consumed energy could still be the same. Even if it could be possible to save some power, no estimates have been provided.  Similar issue was discussed before in Rel-16 URLLC WI, and there was no consensus in RAN1 on switching the UE from Cap#2 to Cap#1 would save UE power. |
| Intel | Y | Do not agree with the comments from MediaTek. Longer processing duration does not necessarily imply an increase in power consumption – it’s the relative increase vs. decrease that matters. In this regard, a more important factor is what the baseline is and what is the relative reduction.  For Rel-16 URLLC WI, this question was never tabled as such – the lack of consensus was for whether to pursue some particular designs motivated by the power consumption reduction in the context of URLLC use-cases. |

### 7.5.4 Analysis of coexistence with legacy UEs

The following potential coexistence impacts were identified in the contributions:

* C1: May make scheduler more complex [1, 2, 23, 24]
* C2: Identification of RedCap UEs before Msg3 may be needed [3, 8, 9, 10, 15].

This potential impact has been moved here from Section 7.5.3 of this document where it was known as P4:

* C3: Contributions [1, 4, 6, 23, 24, 26] observe negative impacts of relaxed UE processing time on scheduling complexity, especially when taking into account different scheduling timing restriction related to N1/N2 and the fact that there already exist two UE processing time capabilities in NR.

Contributions [1, 2, 23, 24] express that multiple UE processing timelines may increase complexity at the scheduler to handle and ensure coexistence with legacy UEs.

Contributions [1, 5, 8, 9, 10, 11, 15, 16, 21, 24] observe that there can be potential coexistence issues with legacy UEs during initial access/random access if a new, more relaxed UE processing time capability is introduced. For example, there exist the timing requirement for scheduling of Msg3 which depends on N1 and N2 values of UE processing time capability #1. If gNB schedules according to legacy UEs, RedCap UEs with relaxed N1/N2, if supported, may not be able to access the cell. On the other hand, if gNB considers potential presence of UEs with relaxed processing time in a cell, it would schedule according to the worst-case timing which would degrade the performance of legacy UEs. Similarly, timing of HARQ-ACK for Msg4 is also identified as a potential coexistence issue with legacy UEs in contributions [8, 9, 10, 15]. In order to support relaxed UE processing time capability during initial access, contributions [3, 8, 9, 10, 15] mention that methods for identifying RedCap UEs, e.g., before Msg3 scheduling may need to be studied.

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| In scenarios where RedCap UEs coexist with legacy UEs, relaxed UE processing time capability for RedCap UEs can have negative impacts on the flexibility and complexity for the scheduling. Given that there already exist two UE processing time capabilities in NR, if yet another UE proessing time capability is introduced, the scheduler would have to consider up to three different UE processing timelines when handling different scheduling timing restriction related to N1 and N2.  The relaxed UE processing time capability, if introduced, can also cause potential coexistence issues with legacy UEs during initial access. The timing relationships between Msg2 and Msg3 and between Msg4 and its HARQ-ACK feedback are determined by the N1 and N2 values. If gNB schedules all UEs according to relaxed timing relationships for RedCap UEs, legacy UEs may experience a performance degradation. In order to support relaxed UE processing time capability during initial access, identification of RedCap UEs before Msg3 may be needed. |

**FL3: Phase 3: Question 7.5.4-2: Can the above observations of coexistence impacts of relaxed UE processing time be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| FL | Clarification: Note that the question concerns the TP right above the question, not the bullet lists above the TP. | |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y mostly | Change ‘can’ to ‘may’ |
| Nokia, NSB | Y |  |
| SONY | Y | Suggested typo:  when handling different scheduling timing restrictions related to N1 and N2. |
| FUTUREWEI4 | almost | The tone of this one is overly negative compared to the other descriptions. Suggest to simplify the first paragraph. |
| Qualcomm | Y |  |
| Intel | N | We are not convinced of the negative impacts on flexibility and complexity of scheduling – the NR base station already handles effectively many timelines (not just two) – each special case and margin associated to it effectively imposes a different timeline constraint (and there are many such exceptions) – just saying “two to three processing timelines” would be misleading.  Suggest the following updates:  In scenarios where RedCap UEs coexist with legacy UEs, relaxed UE processing time capability for RedCap UEs ~~can have negative impacts on the flexibility and~~ may increase the complexity for the scheduling. ~~Given that there already exist two UE processing time capabilities in NR, if yet another UE proessing time capability is introduced, the scheduler would have to consider up to three different UE processing timelines when handling different scheduling timing restriction related to N~~~~1~~ ~~and N~~~~2~~~~.~~  The relaxed UE processing time capability, if introduced, ~~can also~~ may cause potential coexistence issues with legacy UEs during initial access if early identification of RedCap UEs prior to RAR scheduling is not supported. The timing relationships between Msg2 and Msg3 and between Msg4 and its HARQ-ACK feedback are determined by the N1 and N2 values. If gNB schedules all UEs according to relaxed timing relationships for RedCap UEs, legacy UEs may experience an increase in control plane latency. ~~a performance degradation. In order to support relaxed UE processing time capability during initial access, identification of RedCap UEs before Msg3 may be needed.~~ |

### 7.5.5 Analysis of specification impacts

The following potential specification impacts were identified in the contributions:

* S1: Definition of relaxed UE processing time capability and N1/N2 values [1, 2, 3, 4, 13, 15, 23, 24]
* S2: Scheduling time related to default TDRA tables and HARQ-ACK timing range [5, 9, 16, 21, 24]

Contributions [1, 2, 3, 4, 13, 15, 23, 24] mention the specification impact of defining a new relaxed UE processing time capability and new values of N1/N2. Contributions [2, 23] note that the standardization effort can be high as it requires inputs and agreement from all UE manufacturers.

Other potential impacts on scheduling timing related to the existing default TDRA tables and HARQ-ACK timing range are mentioned by contributions [5, 9, 16, 21, 24]. On the other hand, contributions [1, 3, 4] note that no specification impacts beyond new definition of relaxed UE processing time are expected unless the relaxation of N1/N2 values is too excessive.

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| A new UE processing time capability needs to be defined if relaxed UE processing time is introduced. New values of N1 and N2, as well as how the PDSCH processing time and PUSCH preparation time are determined by N1 and N2, need to be defined.  Different scheduling time restrictions related to N1 and N2 values may need to be specified for RedCap UEs, e.g. for the timing relationships between Msg2 and Msg3 and between Msg4 and its HARQ-ACK feedback. Depending on the degree of relaxation of the N1 and N2 values, specification details on scheduling timing related to the default TDRA tables and HARQ-ACK timing range may also need to be updated. |

**FL3: Phase 3: Question 7.5.5-2: Can the above observations of specification impacts of relaxed UE processing time be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| Samsung | Y |  |
| FL | Clarification: Note that the question concerns the TP right above the question, not the bullet lists above the TP. | |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| Qualcomm | Y |  |
| Intel | Y |  |

## 7.6 Relaxed maximum number of MIMO layers

### 7.6.1 Description of feature

RAN1#103e agreement:

* Adopt the TP in [R1-2009393](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009393.zip) as baseline text for TR clause 7.6.1.

### 7.6.2 Analysis of UE complexity reduction

RAN1#103e agreement:

* Adopt the TP in [R1-2009393](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009393.zip) as baseline text for TR clause 7.6.2.

### 7.6.3 Analysis of performance impacts

RAN1#103e agreement:

* TPs corresponding to Questions 7.6.3-2/3a/4a/5a in R1-2009651 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/R1-2009651.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009651.zip)).

**Power consumption:**

* P11: In [1], it is noted that Reducing the maximum DL/UL modulation order and/or DL MIMO support may reduce power consumption due to reduced complexity in processing a smaller maximum TB. However, the amount of power saved may not be significant if the RedCap UEs would mostly be in RRC\_IDLE/INACTIVE states. Furthermore, reducing the maximum number of DL MIMO layers can fulfil the date rate requirements of most RedCap uses cases. In many use cases, long transmission times for large TB sizes are not expected to occur frequently for RedCap use cases. Thus, a negative impact on UE power consumption is not expected. In use cases where large TB sizes occur more often, and long transmission times might become a consequence of modulation order and MIMO layer reduction for UEs in good coverage. In such cases, there will be more pronounced negative impact on UE power consumption. In summary, the impact on UE power consumption depends on the traffic and coverage scenarios.
* P12: Reduced power consumption as higher data rate consume higher power or less processing energy is required for smaller TB sizes [1, 4, 13].
* P13: No impacts on power consumption [24].
* P14: As the number of DL antennas is kept the same, there is no power saving. And since the data rate is reduced, longer receiving time is needed to receive a DL TB. Thus, it will have negative impact on UE power saving [15].

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| **Power consumption:**  The reduced number of MIMO layers can result in a lower instantaneous power consumption due to the reduced peak data rate and reduced complexity in processing a smaller maximum transport block size. |

**Phase 2: Question 7.6.3-6: Can the above observations of the impact on the power consumption for UE with relaxed maximum number of MIMO layers be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| ZTE | Y |  |
| vivo | N | The 2nd sentence is definitely not true. TR38.840 had concluded the power saving benefit by reducing the number of MIMO layers. |
| SONY5 | Y | In response to vivo: wasn’t the TR38.840 conclusion based on certain assumptions? In the Redcap case, for a UE in channel conditions that would support 2 layers, if the Redcap UE only supported a single layer, wouldn’t the UE need to be “on” for longer, thereby increasing power consumption? |
| FUTUREWEI |  | Not sure this one is correct |
| DOCOMO | Y |  |
| Sierra Wireless | Y |  |
| Samsung | N | We don’t agree on the power consumption reduction. We sugget to change to:  The UE power comsumption impact is not clear. |
| Ericsson | Y |  |
| Intel | N | While the second statement may be true in general, we do not think it applies for the UE BW and data rate requirements we are considering for RedCap use-cases. Thus, to SONY’s comment, the UE need not be “ON” for longer only if the traffic demands dictate such, and we do not see such for the targeted data rates and traffic models considered for RedCap. |
| CATT | Y |  |
| Huawei, HiSilicon | Y |  |
| FL | The proposal has been updated based on received responses.  **FL2: Phase 2: Question 7.6.3-6a: Can the above observations of the impact on the power consumption for UE with relaxed maximum number of MIMO layers be used as a baseline text for TR 38.875?** | |
| CATT | Y |  |
| Qualcomm | Y |  |
| vivo | N | Saying something is unclear is confusing to the reader. In section 2.3 of R1-2009212, we provided results assuming MIMO layer is reduced together with number of Rx, and power saving gain is shown for all the agreed traffic model. However, no other evaluations results are available so far showing the power consumption can increase based on the agreed assumptions. |
| ZTE | Y |  |
| Huawei, HiSilicon | Y |  |
| Spreadtrum | Y |  |
| FUTUREWEI3 | Y |  |
| Ericsson | Y |  |
| SONY7 | Y |  |
| Intel | N | Agree with Vivo and prefer to delete the last sentence. For RedCap QoS targets, we do not see possibility of power consumption increase with limited DL MIMO layers. |
| FL | The proposal has been updated based on received responses.  **FL3: Phase 2: Question 7.6.3-6b: Can the above observations of the impact on the power consumption for UE with relaxed maximum number of MIMO layers be used as a baseline text for TR 38.875?** | |
| Ericsson | Y |  |
| vivo | Y |  |
| NEC | Y |  |
| CATT | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| Qualcomm | Y |  |
| MediaTek | N | We don’t agree with the updated proposal, especially by removing the last sentence. There was no evaluation on the how much the power saving could be, and in our view the average power could be increased or decreased based on the traffic characteristics. |
| Intel | Y |  |

### 7.6.4 Analysis of coexistence with legacy UEs

The following potential coexistence impacts were identified in the contributions:

* C1: There is no or no significant coexistence impact. [1, 2, 4, 5, 11, 15]. In [1], it is further noted that prior to the completion of initial access, it is not possible for the gNB to send the rank indication to the UE. Furthermore, a UE’s MIMO layer support could only be known to the gNB after it has retrieved the UE capability from the UE. Due to the limitation in the current specifications, legacy UEs can only be scheduled with single MIMO layer for initial access. Having a RedCap UE with reduced maximum MIMO layer support in the same network, will not affect the number of MIMO layers to be scheduled for the legacy UEs or the RedCap UEs for initial access transmissions.
* C2: Restricted to 2 MIMO layers in FR1 have no obvious coexistence issue is envisioned [3].
* C3: Implicit restrictions on TBS may impact on SIB/Msg4/Paging [24].

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| There is no significant coexistence impact from reduction of the maximum number of MIMO layers for RedCap UEs. |

**FL3: Phase 3: Question 7.6.4-2: Can the above observation of the coexistence impacts for UE with relaxed maximum number of MIMO layers be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| vivo | Y |  |
| NEC | Y |  |
| FL | Clarification: Note that the question concerns the TP right above the question, not the bullet lists above the TP. | |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| Qualcomm | Y |  |
| Intel | Y |  |

### 7.6.5 Analysis of specification impacts

The following potential specification impacts were identified in the contributions:

* S1: UE capability indication to notify the NW of UE’s reduced capability [1, 4, 13].
* S2: Small RAN1 specification impacts [11]
* S3: Limited or no significant specification impacts [2, 15]
* S4: Reduced to 2 MIMO layers in FR1 can provide minimized specification impacts [3].
* S5: No RI and LI report are reduced for single MIMO layer support. Thus, can consider adding the descriptions with report to no RI and LI in the specifications [5].
* S6: Demodulation performance requirements for single layer may be specified in RAN4 [5].

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| The specification impact from reduction of the maximum number of MIMO layers for RedCap UEs is small. |

**FL3: Phase 3: Question 7.6.5-2: Can the above observation of specification impacts for UE with relaxed maximum number of MIMO layers be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| vivo | Y |  |
| NEC | Y |  |
| FL | Clarification: Note that the question concerns the TP right above the question, not the bullet lists above the TP. | |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| Qualcomm | Y |  |
| Intel | Y |  |

## 7.7 Relaxed maximum modulation order

### 7.7.1 Description of feature

RAN1#103e agreement:

* Adopt the TP in [R1-2009394](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009394.zip) for TR clause 7.7.1.

### 7.7.2 Analysis of UE complexity reduction

RAN1#103e agreement:

* Adopt the TP in [R1-2009393](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009393.zip) as baseline text for TR clause 7.7.2.
  + Companies are invited to double-check their entries in the cost reduction spreadsheet with respect to the above comments (and to catch potential typos).
  + The table will be further updated with potential updated cost estimates.

### 7.7.3 Analysis of performance impacts

RAN1#103e agreement:

* TPs corresponding to Questions 7.7.3-2/4a/5/6a in R1-2009651 ([Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/R1-2009651.zip), [Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009651.zip)).

**Network capacity and spectral efficiency:**

* P8: [1] noted that Spectral efficiency is expressed as bit rates per Hz, as reducing the maximum modulation orders in DL/UL will decrease the peak data rates. It is expected that reducing the maximum number of MIMO layers will degrade the spectral efficiency. However, as higher MIMO layers are scheduled when SNR is relatively high. Thus, impacts on spectral efficiency may only be observed under good channel conditions.
* P9: Cell spectral efficiency will be impacted/reduced due to reduced data rate/throughput [1, 2, 4, 5, 6, 11, 15, 24].
* P10: [2] noted the impact on spectral efficiency will be substantial. [3, 11] further observed substantial cell spectral efficiency loss about 23.6% - 43.6% due to UL modulation order restriction from 64QAM to 16QAM in FR1 and about 6.43% spectral efficiency reduction due to DL modulation order restriction from 256QAM to 64QAM in FR1.
* P11: Capacity will be impacted/reduced due to reduced data rate [5, 24].

Based on submitted contributions and email discussion responses, the following TP can be considered. More text on network capacity and spectral efficiency can be captured after further progression of the discussion under AI 8.6.3.

|  |
| --- |
| **Network capacity and spectral efficiency:**  Relaxation of maximum mandatory modulation orders will reduce spectral efficiency due to reduced peak data rate. Quantitative evaluation results are provided in clause X. |

**Phase 2: Question 7.7.3-3: Can the above observations of the impact on network capacity and spectral efficiency for UE with relaxed maximum modulation orders be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| LG | Y |  |
| ZTE | Y |  |
| vivo | Y |  |
| SONY5 | Y |  |
| FUTUREWEI | Y |  |
| DOCOMO | Y |  |
| Sierra Wireless | Y |  |
| Samsung | Y |  |
| Ericsson | Y |  |
| Intel | Y |  |
| OPPO | Y |  |
| CATT | Y |  |
| Huawei, HiSilicon | Y |  |
| FL | **FL2: Phase 2: Question 7.7.3-3: Can the above observations of the impact on network capacity and spectral efficiency for UE with relaxed maximum modulation orders be used as a baseline text for TR 38.875?** | |
| CATT | Y |  |
| Qualcomm | N | The impacts on network capacity are not clear, since the network can admit more RedCap UEs with lower data rates. |
| ZTE | Y |  |
| Huawei, HiSilicon | Y |  |
| FUTUREWEI3 | Y |  |
| Ericsson | Y |  |
| SONY7 | Y | Regarding the Qualcomm comment, shouldn’t the network capacity be based on the number of UEs that can be supported with the same data rate? For the same data rate, it seems that the network capacity would be reduced. |
| Intel | Y |  |
| FL | **FL3: Phase 2: Question 7.7.3-3a: Can the above observations of the impact on network capacity and spectral efficiency for UE with relaxed maximum modulation orders be used as a baseline text for TR 38.875?** | |
| Ericsson | Y |  |
| vivo | Y |  |
| NEC | Y |  |
| CATT | Y | Prefer the former one. But can live with this. |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| FUTUREWEI4 | Y | Same comment as CATT |
| Qualcomm | Y |  |
| MediaTek |  | We don’t see a reason for removing the capacity. Once the spectral efficiency is reduced, the supported number of UEs will be reduced (assuming the same data rate for the users). |
| Intel | Y |  |

### 7.7.4 Analysis of coexistence with legacy UEs

The following potential coexistence impacts were identified in the contributions:

* C1: There is no or no significant coexistence impact. [1, 4, 9, 11, 15, 16]. Contribution [1] further noted that During initial access, for the reception of paging indication or broadcasting information (SIBx), PDSCH is not expected to be scheduled with modulation order higher than QPSK. And the scheduling information for Msg3 would be carried in PDCCH using DCI format 0\_1 which allows modulation order <= 16QAM to be sent in the DCI. From modulation order perspective, there will be no impacts by restricting the UL and/or DL maximum modulation order based on the current agreement.
* C2: For the initial access procedure, lower MCS and single layer for broadcast downlink transmission and initial uplink scheduling will be used to ensure decoding performance or poor UE channel condition. In this case, RedCap UEs are still able to finish the access procedure [9].
* C3: Implicit restrictions on TBS may impact on SIB/Msg4/Paging [24].

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| Relaxing the maximum modulation orders for RedCap UEs will have no significant impacts on coexistence with legacy UEs. |

**FL3: Phase 3: Question 7.7.4-2: Can the above observation of coexistence impacts for UE with relaxed maximum modulation orders be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| vivo | Y |  |
| NEC | Y |  |
| FL | Clarification: Note that the question concerns the TP right above the question, not the bullet lists above the TP. | |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| Qualcomm | Y |  |
| Intel | Y |  |

### 7.7.5 Analysis of specification impacts

The following potential specification impacts were identified in the contributions:

* S1: UE capability indication to notify the NW of UE’s reduced capability [1, 4, 13]
* S2: To minimize specification impacts, there should be no optimization (only reuse) of all existing tables [2]. [5] noted that restricting to 64QAM, one possible solution is to reuse the existing 64QAM table.
* S3: Limited specification impacts [15].
* S4: Small RAN1 specification impacts [1, 4, 5, 11, 20, 24]
  + Change of DCI size, CQI table and MCS table due to restricted maximum modulation order is possible but not essential [1, 4].
  + If the maximum modulation order is restricted to 16QAM, new MCS/DCI tables are introduced [5, 20] with lower/higher spectral efficiency for UE specific allocation case [20] to achieve more scheduling flexibility. It is further noted that the standardization effort would be small if the values from Rel-15/16 tables are reused [20].
* S5: RAN4 CQI performance requirement if new CQI tables are introduced [1].

Based on submitted contributions and email discussion responses, the following TP can be considered.

|  |
| --- |
| For RedCap UEs with relaxed maximum modulation orders, optimizations of MCS tables, CQI tables and DCI formats can be considered. If optimizations are introduced, new performance requirements may be necessary in RAN4 specifications. |

**FL3: Phase 3: Question 7.7.5-2: Can the above observations of specification impacts for UE with relaxed maximum modulation orders be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| vivo |  | Not sure if we should imply any optimizations?  Our suggest text would be the following  The specification impact from relaxed maximum modulation orders for RedCap UEs is small. |
| NEC | Y |  |
| FL | Clarification: Note that the question concerns the TP right above the question, not the bullet lists above the TP. | |
| CATT | Y | Considering the features listed above, we do not think the specification impact can be concluded as ‘small’… |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG |  | Those specification impacts that arise from optimization efforts are not essential. And also considering the overall cost/complexity gain that we expect from this feature is minor, the optimizations should not be pursued. Therefore we prefer the wording suggested by vivo. |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| FUTUREWEI4 | N | This is written in a way to promote unnecessary optimizations, and should be re-written: The spec impact is small. Optimizations such as blah blah are not necessary. If optimizations are considered, new performance… |
| Qualcomm |  | Agree with the comments of Vivo and LG |
| Intel | N | Agree with Vivo, LG, and Qualcomm and prefer the version from Vivo. |

## 7.8 Combinations of UE complexity reduction features

### 7.8.1 Description of feature combinations

The following TP on description of combinations of UE complexity reduction techniques can be considered.

|  |
| --- |
| The evaluation results for the studied individual UE complexity reduction techniques are captured in clauses 7.2 through 7.7. In this clause, the properties of combinations of different individual UE complexity reduction techniques are described. |

**FL3: Phase 3: Question 7.8.1-1: Can the above TP on description of combinations of UE complexity reduction techniques be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| Intel | Y |  |

### 7.8.2 Analysis of UE complexity reduction

RAN1#103e agreements:

* For evaluating complexity reduction, to come up with a set of combinations of techniques:
  + For each case (FR1 FDD, FR1 TDD, & FR2), target up to 6 to 8 combinations
    - Detailed combinations are FFS
* For TR section 7.2.2 (on reduced number of Rx antennas), the following combinations of complexity reduction techniques are evaluated.
  1. FR1 FDD: 1 layer, 1 Rx
  2. FR1 TDD: 1 layer, 1 Rx
  3. FR1 TDD: 2 layers, 2 Rx
  4. FR2: 1 layer, 1 Rx
* For FR1 FDD, the following combinations of complexity reduction techniques are evaluated:

1. 1 layer, 1 Rx, 20 MHz
2. 1 layer, 1 Rx, 20 MHz, HD-FDD type A
3. 1 layer, 1 Rx, 20 MHz, relaxed modulations for DL & UL
4. 1 layer, 1 Rx, 20 MHz, doubled processing time for N1 & N2 only
5. 1 layer, 1 Rx, 20 MHz, relaxed modulations for DL & UL, doubled processing time for N1 & N2 only
6. 1 layer, 1 Rx, 20 MHz, relaxed modulations for DL & UL, HD-FDD type A, doubled processing time for N1 & N2 only
7. 2 layers, 2 Rx, 20 MHz, HD-FDD type A
8. 2 layers, 2 Rx, 20 MHz, doubled processing time for N1 & N2 only

* For FR1 TDD, the following combinations of complexity reduction techniques are evaluated:

1. 1 layer, 1 Rx, 20 MHz
2. 1 layer, 1 Rx, 20 MHz, relaxed modulations for DL & UL
3. 1 layer, 1 Rx, 20 MHz, doubled processing time for N1 & N2 only
4. 1 layer, 1 Rx, 20 MHz, relaxed modulations for DL & UL, doubled processing time for N1 & N2 only
5. 2 layers, 2 Rx, 20 MHz
6. 2 layers, 2 Rx, 20 MHz, relaxed modulations for DL & UL
7. 2 layers, 2 Rx, 20 MHz, doubled processing time for N1 & N2 only
8. 2 layers, 2 Rx, 20 MHz, relaxed modulations for DL & UL, doubled processing time for N1 & N2 only

* For FR2, the following combinations of complexity reduction techniques are evaluated:

1. 1 layer, 1 Rx, 100 MHz
2. 1 layer, 1 Rx, 100 MHz, relaxed modulations DL & UL
3. 1 layer, 1 Rx, 100 MHz, doubled processing time for N1 & N2 only
4. 1 layer, 1 Rx, 100 MHz, relaxed modulations DL & UL, doubled processing time for N1 & N2 only
5. 2 layers, 2 Rx, 100 MHz, relaxed modulations DL & UL
6. 2 layers, 2 Rx, 100 MHz, doubled processing time for N1 & N2 only
7. 2 layers, 2 Rx, 100 MHz, relaxed modulations DL & UL, doubled processing time for N1 & N2 only

The tables with device cost evaluation results in this contribution are based on [RedCapCost-v048-FL-Samsung2.xlsx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/drafts/8.6/EvaluationResults/RedCapCost/RedCapCost-v048-FL-Samsung2.xlsx). They will eventually be updated with new results from the email discussion [103-e-NR-RedCap-EvaluationResults].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| The estimated costs and estimated cost reductions for devices employing one or more of the UE complexity reduction techniques (see descriptions in clauses 7.2 through 7.7), relative to the reference NR device (see evaluation methodology described in clause 6.1) and averaged over the results provided by the sourcing companies, are summarized in Table 7.8.2-1 for FR1 FDD, Table 7.8.2-2 for FR1 TDD, and Table 7.8.2-3 for FR2.  **Table 7.8.2-1: Estimated relative device cost and estimated relative device cost reduction for UE complexity reduction technique(s) for FR1 FDD**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | **FR1 FDD UE complexity reduction technique(s)** | **RF cost metric** | **BB cost metric** | **Total cost metric** | **RF reduction** | **BB reduction** | **Total reduction** | | 20 MHz (instead of 100 MHz) | 97.7% | 48.4% | 68.1% | 2.3% | 51.6% | 31.9% | | 1 layer (instead of 2 layers) | 100.0% | 79.3% | 87.6% | 0.0% | 20.7% | 12.4% | | 1 layer, 1 Rx (instead of 2 layers, 2 Rx) | 74.2% | 55.9% | 63.2% | 25.8% | 44.1% | 36.8% | | HD-FDD type A (instead of FD-FDD) | 83.9% | 99.4% | 93.2% | 16.1% | 0.6% | 6.8% | | HD-FDD type B (instead of FD-FDD) | 77.3% | 99.2% | 90.4% | 22.7% | 0.8% | 9.6% | | Double N1 and N2 | 100.0% | 90.5% | 94.3% | 0.0% | 9.5% | 5.7% | | DL 64QAM (instead of DL 256QAM) | 97.8% | 91.8% | 94.2% | 2.2% | 8.2% | 5.8% | | UL 16QAM (instead of UL 64QAM) | 97.1% | 98.3% | 97.8% | 2.9% | 1.7% | 2.2% | | 20 MHz, 1 layer, 1 Rx | 67.5% | 25.8% | 42.5% | 32.5% | 74.2% | 57.5% | | 20 MHz, 1 layer, 1 Rx, HD-FDD type A | 53.2% | 25.6% | 36.6% | 46.8% | 74.4% | 63.4% | | 20 MHz, 1 layer, 1 Rx, DL 64QAM, UL 16QAM | 64.2% | 24.3% | 40.2% | 35.8% | 75.7% | 59.8% | | 20 MHz, 1 layer, 1 Rx, double N1/N2 | 67.5% | 22.9% | 40.7% | 32.5% | 77.1% | 59.3% | | 20 MHz, 1 layer, 1 Rx, DL 64QAM, UL 16QAM, double N1/N2 | 64.6% | 21.7% | 38.9% | 35.4% | 78.3% | 61.1% | | 20 MHz, 1 layer, 1 Rx, DL 64QAM, UL 16QAM, HD-FDD type A, double N1/N2 | 50.2% | 21.4% | 32.9% | 49.8% | 78.6% | 67.1% | | 20 MHz, 2 layers, 2 Rx, HD-FDD type A | 81.3% | 46.0% | 60.1% | 18.8% | 54.0% | 39.9% | | 20 MHz, 2 layers, 2 Rx, double N1/N2 | 97.6% | 42.6% | 64.6% | 2.4% | 57.4% | 35.4% |   **Table 7.8.2-2: Estimated relative device cost and estimated relative device cost reduction for UE complexity reduction technique(s) for FR1 TDD**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | **FR1 TDD UE complexity reduction technique(s)** | **RF cost metric** | **BB cost metric** | **Total cost metric** | **RF reduction** | **BB reduction** | **Total reduction** | | 20 MHz (instead of 100 MHz) | 96.4% | 46.7% | 66.6% | 3.6% | 53.3% | 33.4% | | 2 layers (instead of 4 layers) | 100.0% | 81.1% | 88.7% | 0.0% | 18.9% | 11.3% | | 1 layer (instead of 4 layers) | 100.0% | 71.9% | 83.2% | 0.0% | 28.1% | 16.8% | | 2 layers, 2 Rx (instead of 4 layers, 4 Rx) | 68.0% | 55.4% | 60.4% | 32.0% | 44.6% | 39.6% | | 1 layer, 1 Rx (instead of 4 layers, 4 Rx) | 51.3% | 33.0% | 40.3% | 48.7% | 67.0% | 59.7% | | Double N1 and N2 | 100.0% | 90.1% | 94.1% | 0.0% | 9.9% | 5.9% | | DL 64QAM (instead of DL 256QAM) | 96.2% | 92.1% | 93.7% | 3.8% | 7.9% | 6.3% | | UL 16QAM (instead of UL 64QAM) | 96.9% | 98.4% | 97.8% | 3.1% | 1.6% | 2.2% | | 20 MHz, 1 layer, 1 Rx | 50.6% | 18.6% | 31.4% | 49.4% | 81.4% | 68.6% | | 20 MHz, 1 layer, 1 Rx, DL 64QAM, UL 16QAM | 47.1% | 17.5% | 29.3% | 52.9% | 82.5% | 70.7% | | 20 MHz, 1 layer, 1 Rx, double N1/N2 | 50.6% | 16.2% | 30.0% | 49.4% | 83.8% | 70.0% | | 20 MHz, 1 layer, 1 Rx, DL 64QAM, UL 16QAM, double N1/N2 | 47.1% | 15.3% | 28.1% | 52.9% | 84.7% | 71.9% | | 20 MHz, 2 layers, 2 Rx | 66.8% | 27.8% | 43.4% | 33.3% | 72.2% | 56.6% | | 20 MHz, 2 layers, 2 Rx, DL 64QAM, UL 16QAM | 61.8% | 26.1% | 40.4% | 38.2% | 73.9% | 59.6% | | 20 MHz, 2 layers, 2 Rx, double N1/N2 | 66.8% | 24.9% | 41.7% | 33.3% | 75.1% | 58.3% | | 20 MHz, 2 layers, 2 Rx, DL 64QAM, UL 16QAM, double N1/N2 | 61.8% | 23.7% | 38.9% | 38.2% | 76.3% | 61.1% |   **Table 7.8.2-3: Estimated relative device cost and estimated relative device cost reduction for UE complexity reduction technique(s) for FR2**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | **FR2 UE complexity reduction technique(s)** | **RF cost metric** | **BB cost metric** | **Total cost metric** | **RF reduction** | **BB reduction** | **Total reduction** | | 100 MHz (instead of 200 MHz) | 99.5% | 69.4% | 84.4% | 0.5% | 30.6% | 15.6% | | 50 MHz (instead of 200 MHz) | 99.0% | 54.0% | 76.5% | 1.0% | 46.0% | 23.5% | | 1 layer (instead of 2 layers) | 100.0% | 77.8% | 88.9% | 0.0% | 22.2% | 11.1% | | 1 layer, 1 Rx (instead of 2 layers, 2 Rx) | 64.9% | 55.7% | 60.3% | 35.1% | 44.3% | 39.7% | | Double N1 and N2 | 100.0% | 88.9% | 94.4% | 0.0% | 11.1% | 5.6% | | DL 16QAM (instead of DL 64QAM) | 97.8% | 91.0% | 94.4% | 2.2% | 9.0% | 5.6% | | UL 16QAM (instead of UL 64QAM) | 97.9% | 98.4% | 98.1% | 2.2% | 1.6% | 1.9% | | 100 MHz, 1 layer, 1 Rx | 64.8% | 40.3% | 52.5% | 35.2% | 59.7% | 47.5% | | 100 MHz, 1 layer, 1 Rx, DL 16QAM, UL 16QAM | 61.6% | 37.0% | 49.3% | 38.4% | 63.0% | 50.7% | | 100 MHz, 1 layer, 1 Rx, double N1/N2 | 64.4% | 35.5% | 50.0% | 35.6% | 64.5% | 50.0% | | 100 MHz, 1 layer, 1 Rx, DL 16QAM, UL 16QAM, double N1/N2 | 61.6% | 32.9% | 47.2% | 38.4% | 67.1% | 52.8% | | 100 MHz, 2 layers, 2 Rx, DL 16QAM, UL 16QAM | 95.2% | 63.8% | 79.5% | 4.8% | 36.2% | 20.5% | | 100 MHz, 2 layers, 2 Rx, double N1/N2 | 99.4% | 62.4% | 80.9% | 0.6% | 37.6% | 19.1% | | 100 MHz, 2 layers, 2 Rx, DL 16QAM, UL 16QAM, double N1/N2 | 95.2% | 57.8% | 76.5% | 4.8% | 42.2% | 23.5% | |

**FL1: Phase 1: Proposal 7.8.2-1: Adopt the TP above as baseline text for TR clause 7.8.2.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| FUTUREWEI2 | Y |  |
| Ericsson | Y |  |
| Qualcomm | Y |  |
| Intel | Y |  |
| Nokia, NSB | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| CATT | Y mostly | In **Table 7.8.2-1,** relaxed modulation in *combinations* is marked as ‘DL 64QAM, UL 16QAM’, while in **Table 7.8.2-2** and **Table 7.8.2-3,** it is marked as ‘relaxed mods’.  We prefer to make them aligned, e.g., for **Table 7.8.2-2**, change to ‘DL 64QAM, UL 16QAM’, and for **Table 7.8.2-3,** change to ‘DL 16QAM, UL 16QAM’, respectively. |
| SONY6 | Y |  |
| CMCC | Y |  |
| ZTE | Y |  |
| OPPO | Y | Agree with CATT’s proposal |
| Samsung | N | It is not clear on what is MIMO layer assumption on 1Rx (instead of 2 Rx).  And We don’t agree to capture it in conclusion part. |
| Huawei, HiSilicon | Y |  |
| Spreadtrum | Y |  |
| FL | **FL3: Phase 1: Proposal 7.8.2-1a: Adopt the TP above as baseline text for TR clause 7.8.2.** | |
| Ericsson | Y |  |
| Samsung | Y |  |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| Xiaomi | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| Qualcomm | Y |  |
| MediaTek | Y |  |
| Intel | Y |  |

### 7.8.3 Analysis of performance impacts

The following format for a TP on peak data rate impacts from combinations of UE complexity reduction techniques can be considered.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Peak data rate:**  Reducing the maximum number of downlink MIMO layers (with or without reducing the number of Rx branches) will lower the downlink peak data rate.   * Reduction from 2 layers to 1 layer decreases the downlink peak rate by ~50%. * Reduction from 4 layers to 2 layers decreases the downlink peak rate by ~50%. * Reduction from 4 layers to 1 layer decreases the downlink peak rate by ~75%.   Reducing the maximum UE bandwidth will lower the downlink peak data rate.   * Reduction from 100 MHz to 20 MHz decreases the downlink peak rate by ~80%. * Reduction from 200 MHz to 100 MHz decreases the downlink peak rate by ~50%. * Reduction from 200 MHz to 50 MHz decreases the downlink peak rate by ~75%.   Reducing the maximum modulation orders will lower the peak data rate.   * Reduction from 256QAM to 64QAM decreases the peak rate by ~25%. * Reduction from 64QAM to 16QAM decreases the peak rate by ~33%.   The resulting peak rates for some combinations of UE complexity reduction techniques are shown in Tables 7.8.3-1, 7.8.3-2 and 7.8.3-3 for FR1 FDD, FR1 TDD and FR2, respectively.  **Table 7.8.3-1: Peak data rate impacts from UE complexity reduction techniques for FR1 FDD**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **FR1 FDD UE complexity reduction technique(s)** | **15 kHz SCS** | | **30 kHz SCS** | | | **DL** | **UL** | **DL** | **UL** | | 20 MHz (instead of 100 MHz) | TBD | TBD | TBD | TBD | | 1 layer (instead of 2 layers) | TBD | TBD | TBD | TBD | | DL 64QAM (instead of DL 256QAM) | TBD | TBD | TBD | TBD | | UL 16QAM (instead of UL 64QAM) | TBD | TBD | TBD | TBD | | 20 MHz, 1 layer | TBD | TBD | TBD | TBD | | 20 MHz, DL 64QAM | TBD | TBD | TBD | TBD | | 20 MHz, UL 16QAM | TBD | TBD | TBD | TBD | | 20 MHz, DL 64QAM, UL 16QAM | TBD | TBD | TBD | TBD | | 20 MHz, 1 layer, DL 64QAM | TBD | TBD | TBD | TBD | | 20 MHz, 1 layer, UL 16QAM | TBD | TBD | TBD | TBD | | 20 MHz, 1 layer, DL 64QAM, UL 16QAM | TBD | TBD | TBD | TBD |   **Table 7.8.3-2: Peak data rate impacts from UE complexity reduction techniques for FR1 TDD**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **FR1 TDD UE complexity reduction technique(s)** | **15 kHz SCS** | | **30 kHz SCS** | | | **DL** | **UL** | **DL** | **UL** | | 20 MHz (instead of 100 MHz) | TBD | TBD | TBD | TBD | | 2 layers (instead of 4 layers) | TBD | TBD | TBD | TBD | | 1 layer (instead of 4 layers) | TBD | TBD | TBD | TBD | | DL 64QAM (instead of DL 256QAM) | TBD | TBD | TBD | TBD | | UL 16QAM (instead of UL 64QAM) | TBD | TBD | TBD | TBD | | 20 MHz, 2 layers | TBD | TBD | TBD | TBD | | 20 MHz, 1 layer | TBD | TBD | TBD | TBD | | 20 MHz, DL 64QAM | TBD | TBD | TBD | TBD | | 20 MHz, UL 16QAM | TBD | TBD | TBD | TBD | | 20 MHz, DL 64QAM, UL 16QAM | TBD | TBD | TBD | TBD | | 20 MHz, 2 layers, DL 64QAM | TBD | TBD | TBD | TBD | | 20 MHz, 2 layers, UL 16QAM | TBD | TBD | TBD | TBD | | 20 MHz, 2 layers, DL 64QAM, UL 16QAM | TBD | TBD | TBD | TBD | | 20 MHz, 1 layer, DL 64QAM | TBD | TBD | TBD | TBD | | 20 MHz, 1 layer, UL 16QAM | TBD | TBD | TBD | TBD | | 20 MHz, 1 layer, DL 64QAM, UL 16QAM | TBD | TBD | TBD | TBD |   **Table 7.8.3-3: Peak data rate impacts from UE complexity reduction techniques for FR2**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **FR2 UE complexity reduction technique(s)** | **60 kHz SCS** | | **120 kHz SCS** | | | **DL** | **UL** | **DL** | **UL** | | 100 MHz (instead of 200 MHz) | TBD | TBD | TBD | TBD | | 1 layer (instead of 2 layers) | TBD | TBD | TBD | TBD | | DL 16QAM (instead of DL 64QAM) | TBD | TBD | TBD | TBD | | UL 16QAM (instead of UL 64QAM) | TBD | TBD | TBD | TBD | | 100 MHz, 1 layer | TBD | TBD | TBD | TBD | | 100 MHz, DL 16QAM | TBD | TBD | TBD | TBD | | 100 MHz, UL 16QAM | TBD | TBD | TBD | TBD | | 100 MHz, DL 16QAM, UL 16QAM | TBD | TBD | TBD | TBD | | 100 MHz, 1 layer, DL 16QAM | TBD | TBD | TBD | TBD | | 100 MHz, 1 layer, UL 16QAM | TBD | TBD | TBD | TBD | | 100 MHz, 1 layer, DL 16QAM, UL 16QAM | TBD | TBD | TBD | TBD | |

An updated TP with values will be proposed after the format has been agreed.

**FL3: Phase 3: Question 7.8.3-1: Can the above TP on peak data rate impacts for combinations of UE complexity reduction techniques be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| vivo |  | There maybe no need to have this excersice to calculate all the data rates for different combinations, as the data rate reduction for each individual feature is clear. |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE |  | Above TP should be determined after the deicision of modulation order and MIMO layer |
| Nokia, NSB | Y |  |
| SONY | Y | What is the process for resolving the TBD values? |
| FUTUREWEI4 | N | Agree with Vivo. No need to include the tables. |
| Qualcomm |  | Agree with Vivo |
| Intel | N | Agree with Vivo and others; we do not see a need for this exercise. |

The following TP on other performance impacts from combinations of UE complexity reduction techniques can be considered.

|  |
| --- |
| **Other performance impacts:**  For impacts on coverage, network capacity, spectral efficiency, data rate, latency, reliability, power consumption and PDCCH blocking probability from each UE complexity reduction technique, refer to clauses 7.2 through 7.7.  Quantitative evaluation results for coverage, network capacity and spectral efficiency are provided in clauses 9 and X. |

**FL3: Phase 3: Question 7.8.3-2: Can the above TP on performance impacts for combinations of UE complexity reduction techniques be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| vivo | Y |  |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| Qualcomm |  | Can we clarify the definition of “network capacity” first ? |
| Intel | Y |  |

### 7.8.4 Analysis of coexistence with legacy UEs

The following TP on coexistence impacts from combinations of UE complexity reduction techniques can be considered.

|  |
| --- |
| For coexistence impacts from each UE complexity reduction technique, refer to clauses 7.2 through 7.7. |

**FL3: Phase 3: Question 7.8.4-1: Can the above TP on coexistence impacts for combinations of UE complexity reduction techniques be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| vivo | Y |  |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y |  |
| Qualcomm | Y |  |
| Intel | Y |  |

### 7.8.5 Analysis of specification impacts

The following TP on specification impacts from combinations of UE complexity reduction techniques can be considered.

|  |
| --- |
| For specification impacts from each UE complexity reduction technique, refer to clauses 7.2 through 7.7. |

**FL3: Phase 3: Question 7.8.5-1: Can the above TP on specification impacts for combinations of UE complexity reduction techniques be used as a baseline text for TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Ericsson | Y |  |
| vivo | Y |  |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| SONY | Y |  |
| Qualcomm | Y |  |
| Intel | Y |  |

# 12 Conclusions

RAN1#103e agreements:

* Capture the recommendation that maximum bandwidth of an FR1 RedCap UE is 20 MHz during and after initial access.
  + FFS: Whether an FR1 RedCap UE can optionally support a maximum bandwidth larger than 20 MHz after initial access
* Working assumption: Support that the maximum bandwidth of an FR2 RedCap UE is 100 MHz during initial access and 100MHz after initial access.
* Confirm the working assumption: Support that the maximum bandwidth of an FR2 RedCap UE is 100 MHz during initial access and 100MHz after initial access.
* For FR1 FDD bands where a non-RedCap UE is required to be equipped with a minimum of 2 Rx branches,
  + The minimum number of Rx branches supported by specification for a RedCap UE is 1.
  + Specification also supports of 2 Rx branches for a RedCap UE.
* For FR1 TDD bands where a non-RedCap UE is required to be equipped with a minimum of 4 Rx branches, the minimum number of Rx branches supported by specification for a RedCap UE is N. To be down-selected during the WI phase or at RAN plenary:
  + Alt 1: N=2
  + Alt 2: N=1, where N=2 is also supported

Based on submitted input (contributions, evaluation results, email discussion responses), the following can be considered.

**Phase 1: Proposal 12-60: Support that the minimum number of Rx branches of an FR2 RedCap UE is 1.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| CATT | Y | Also fine to wait for conclusions from cost evaluations of combinations. |
| LG | Y |  |
| ZTE | Y |  |
| vivo | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | almost | The results here seem not so stable, and we may need to discuss how much compensation we would apply in this case.  Our comment from the last FLS still applies … we may be ok to support 1RX as long as 2RX/2MIMO layers is also supported as part of UE capability signaling. |
| Qualcomm | Y |  |
| DOCOMO | Y |  |
| InterDigital | Y |  |
| Samsung | Y |  |
| Ericsson | Y |  |
| Sharp | Y |  |
| Intel | Y |  |
| Spreadtrum | Y |  |
| OPPO | Y |  |
| NEC | Y |  |
| Xiaomi | Y |  |
| FL | Based on received responses, the following proposal can be considered as a way forward.  **FL1: Phase 1: Proposal 12-61: Recommend that the specification supports RedCap UEs with 1 Rx branch as well as RedCap UEs with 2 Rx branches for FR2 bands where a non-RedCap UE is required to be equipped with a minimum of 2 Rx branches.** | |
| FUTUREWEI2 | Y | We can accept this, though our preference as expressed in the GTW is to decide now that initial access is based on 1RX and 2RX can be indicated as a UE capability. |
| MediaTek | N | We don’t support the proposal. If we don’t define different RedCap UEs, the gNB will have to assume 1Rx RedCap UEs. So, not sure what this will add compared to mandating the UE to support at least 1 Rx.  We do not see a need to introduce market fragmentation, especially if the same approach is adopted to other reduction features.  We should down select between the two options (1Rx or 2Rx). |
| Ericsson | Y |  |
| Qualcomm | Y |  |
| Intel | Y |  |
| Nokia, NSB | N | We are not sure why 2Rx is needed here. As FL’s proposal is to support both 1Rx and 2Rx, we’d likely have to do coverage recovery for the 1Rx case anyway. So we don’t know why we need to also support 2Rx. |
| DOCOMO | Y |  |
| LG | Y | We can accept this proposal. We think 1Rx needs to be supported anyway perhaps with optional 2Rx, but we can discuss this later on. |
| CATT | Y | We can live with this for the sake of progress. |
| Lenovo, Motorola Mobility | Y |  |
| vivo | N | The previous version (**Phase 1: Proposal 12-60**) of proposal were supported by all companies, not sure the reason for the update. The previous one should be taken. |
| NEC | Y |  |
| CMCC | Y |  |
| ZTE | Y |  |
| OPPO |  | One RX shall be supported for FR2.  We don’t see clear motivation to support 2RX in FR2. |
| Samsung | N | We think N=1 should be supported as the **minimum** number of RX branches.  Same question as Vivo. We think we should go back to (**Phase 1: Proposal 12-60** |
| Huawei, HiSilicon | Y |  |
| FL | Based on received responses, the following proposal can be considered as a way forward. The formulation is aligned with the corresponding agreement for the FR1 FDD case.  **FL3: Phase 1: Proposal 12-62:**   * **For FR2 bands where a non-RedCap UE is required to be equipped with a minimum of 2 Rx branches,**   + **The minimum number of Rx branches supported by specification for a RedCap UE is 1.**   + **Specification also supports of 2 Rx branches for a RedCap UE.** | |
| Ericsson | Y |  |
| vivo | Y |  |
| Samsung | Y |  |
| NEC | Y |  |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| Xiaomi | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y | Our preference is not to support 2Rx for FR2 bands. However, we can accept this proposal to make progress. |
| FUTUREWEI4 | Y | The handling of FR2 may not need to mirror FR1 FDD, but can accept. |
| Qualcomm | Y |  |
| MediaTek | Y |  |
| Intel | Y | Same view as Nokia. |
| Lenovo, Motorola Mobility | Y |  |

**Phase 1: Proposal 12-70: Support that the minimum number of supported DL MIMO layers of an FR1 FDD RedCap UE is 1.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Huawei, HiSilicon | N | Wait. We envision that the support 2Rx&2Layers in FDD FR1 for RedCap is important. It should be decided together with the support of 1Rx&1 Layer. |
| CATT | Y | Also fine to wait for conclusions from cost evaluations of combinations. |
| LG | Y |  |
| ZTE | Y |  |
| vivo | Y |  |
| Nokia, NSB | Y |  |
| SONY5 | Y |  |
| FUTUREWEI | almost | 2RX/2MIMO layers also is supported by UE capability |
| Qualcomm | Y |  |
| DOCOMO | Y |  |
| InterDigital | Y |  |
| Sierra Wireless | Y |  |
| Samsung |  | No need to make recommendation for MIMO layer reduction itself. But OK with 1 Rx |
| Ericsson | Y |  |
| Sharp | Y |  |
| Intel | Y |  |
| Spreadtrum | Y |  |
| OPPO | Y |  |
| NEC | Y |  |
| Xiaomi | Y |  |
| FL | Based on received responses, the following proposal can be considered as a way forward.  **FL1: Phase 1: Proposal 12-71: Recommend that the specification supports RedCap UEs with max 1 DL MIMO layer as well as RedCap UEs with max 2 DL MIMO layers for FR1 FDD bands where a non-RedCap UE is required to be equipped with a minimum of 2 Rx branches.** | |
| FUTUREWEI | Y | We can accept this for progress, though more discussion may be needed later on the relation of RX and layer (e.g., is 2RX always 2 layer, or can also be 1 layer) |
| MediaTek | N | Number of DL MIMO layers should be the same as the #Rx. Please see our input to “FL1: Phase 1: Proposal 12-21”. |
| Ericsson | Y | We would also be fine to add a sub-bullet stating that the UE is not required to support a higher number of DL MIMO layers than the number of Rx branches, although it seems somewhat obvious. |
| Qualcomm | N | As far as UE capability is concerned for RedCap devices, we don’t support MIMO layer reduction beyond the number of RX antennas.  As a compromise, we can accept the following proposal:  *For FR1 FDD bands where a non-RedCap UE is required to be equipped with a minimum of 2 Rx branches, recommend that the specification supports RedCap UEs with 1 RX branch and max 1 DL MIMO layer.*  *FFS the support for RedCap UEs with 2 RX branches and max 2 DL MIMO layer for FR1 FDD bands where a non-RedCap UE is required to be equipped with a minimum of 2 Rx branches.* |
| Intel | Y | We support the proposal and do not agree to the idea that a UE should be mandated to support more than 1 layers for 2Rx cases, when there is no need from data rate perspective and can provide meaningful cost/complexity savings. |
| Nokia, NSB | Y | We think that the number of DL MIMO layers should be the same as the number of Rx antennas. But we are OK to accept this. |
| DOCOMO | Y | Share the same view with Intel |
| LG | Y | Also fine with the suggested addition from Ericsson. |
| CATT | Y | We can live with this for the sake of progress. |
| SONY6 | Y | Agree with Ericsson |
| Lenovo, Motorola Mobility | Y |  |
| vivo | N | The previous version (**Phase 1: Proposal 12-60**) of proposal were supported by all companies, not sure the reason for the update. The previous one should be taken. |
| NEC | Y |  |
| CMCC | Y |  |
| ZTE | Y | 2 MIMO layers could not be mandatory for 2Rx UE. |
| OPPO | N | The number of DL MIMO layers should be the same as the number of Rx antennas.  Agree with Qualcomm’s proposal as a compromise. |
| Samsung | N | We support 1 layer with 1 Rx.  We should agreed on # of Rx first and then discuss whether more relax of MIMO layer is needed or not.  We should go back to Proposal 12-60 |
| Sequans | Y | Same view as Intel |
| Huawei, HiSilicon | Y |  |
| Spreadtrum |  | Number of DL MIMO layers should be the same as the #Rx |
| FL | Based on received responses, the following proposal can be considered as a way forward.  **FL3: Phase 1: Proposal 12-22:**   * **For FR1 FDD bands where a non-RedCap UE is required to be equipped with a minimum of 2 Rx branches,**   + **For a RedCap UE with 1 Rx branch, the maximum number of DL MIMO layers is 1.**   + **For a RedCap UE with 2 Rx branches, the maximum number of DL MIMO layers is *M*.** **Down-select between the following options during RAN1#103e:**     - **Option A: *M*=1**     - **Option B: *M*=1, with *M*=2 as an optional capability**     - **Option C: *M*=2** | |
| Ericsson | Y | We prefer Option C. |
| vivo | Y | Prefer B |
| Samsung |  | We are OK for the proposal. For downselect for three options, we wupport Option C, M=2. |
| NEC | Y | Option B |
| CATT | Y | We prefer Option C. |
| CMCC | Y | Option C |
| DOCOMO | Y | We prefer Option B but can live with Option C |
| Xiaomi | Y | Option B |
| LG | Y | Option C |
| ZTE | Y | Option B |
| Nokia, NSB | Y | Option C |
| SONY | Y | Option B. The complexity analysis for the reduced number of MIMO layers technique seems to give about 10% complexity gain, so we think it is worth at least having the possibility to operate with M = 1. |
| FUTUREWEI4 | Y | Option C |
| Qualcomm | Y | Option C |
| MediaTek | Y | We prefer Option C. |
| Intel | Y | Option B; same observation as SONY. |
| Lenovo, Motorola Mobility | Y | Option C |
| Sierra Wireless | Y | Option C |

**Phase 1: Question 12-80: If RAN1 recommends 2 Rx for FR1 TDD, should RAN1 recommend 1 or 2 layers for FR1 TDD?**

|  |  |  |
| --- | --- | --- |
| **Company** | **1 or 2** | **Comments or suggested revisions** |
| Huawei, HiSilicon | Y | We are ok with #Layers=#Rx, i.e. 2 Layers. |
| CATT | 2 |  |
| CMCC | 2 layers |  |
| LG | 2 |  |
| ZTE |  | 1 MIMO layer is mandatory and 2 MIMO layers could be an optional capability. |
| vivo | 1 | Agree with ZTE |
| Nokia, NSB | 2 layers |  |
| SONY5 | 1 | Agree with ZTE, vivo |
| FUTUREWEI | 2 |  |
| Qualcomm |  | We don’t think DL MIMO layer reduction beyond the number of RX branches should be supported.  1 RX branch and 1 DL MIMO layer should be recommended as the minimum UE capabilities in FR1.  We are fine to support 2 RX branches and 2 DL MIMO layers as optional instead of minimum UE capabilities for RedCap devices. |
| DOCOMO |  | Agree with ZTE |
| InterDigital | Y | Agree with ZTE. |
| Sierra Wireless | 2 | Prefer to have # of layers = # Rx |
| Samsung |  | No need to make recommendation if # layer =# of Rx |
| Ericsson |  | No strong view |
| Sharp | 2 layers | As the combinations of complexity reduction techniques for evaluation, the number of layers is equal to the number of RXs. |
| Intel | 1 layer | 1 layer should be requirement; 2 layers can be UE capability for bands wherein UE is either: required to support, or optionally supports, 2Rx.  We do not agree to mandating 2 layers for FR1 TDD which is entirely unnecessary.  Also, the proposal as it stands, seems to indicate we might even end up requiring 2 layers in certain FR1 TDD bands with 1Rx support, but this may not be relevant if we go with 1 DL MIMO layer as the mandatory requirement. |
| Spreadtrum |  | Agree with ZTE |
| OPPO | 2 layers | What is the motivation to support 2Rx in FR1 TDD?  If it is for boosting peak data rate, 2 layer shall be supported for UE with 2RX. |
| NEC | 1 or 2 | Capability per CC |
| Xiaomi |  | Same view with ZTE |
| FL | Based on received responses, the following proposal can be considered as a way forward.  **FL1: Phase 1: Proposal 12-81: Recommend that the specification supports RedCap UEs with max 1 DL MIMO layer as well as RedCap UEs with max 2 DL MIMO layers for FR1 TDD bands where a non-RedCap UE is required to be equipped with a minimum of 4 Rx branches.** | |
| FUTUREWEI | Y | We can accept this for progress, though more discussion may be needed later on the relation of RX and layer (e.g., is 2RX always 2 layer, or can also be 1 layer) |
| MediaTek | N | DL MIMO layers reduction beyond the number of Rx branches shouldn’t be supported. |
| Ericsson | Y | We would also be fine to add a sub-bullet stating that the UE is not required to support a higher number of DL MIMO layers than the number of Rx branches, although it seems somewhat obvious. |
| Qualcomm | Y partially | For clarity, we suggest the following changes for this proposal:  *For FR1 TDD bands where a non-RedCap UE is required to be equipped with a minimum of 4 Rx branches, recommend that the specification supports RedCap UEs with max 1 DL MIMO layer and 1 RX branch, as well as RedCap UEs with max 2 DL MIMO layers and 2 RX branches.* |
| Intel | Y |  |
| Nokia, NSB | Y | We think that the number of DL MIMO layers should be the same as the number of Rx antennas. But we are OK to accept this. |
| DOCOMO | Y |  |
| LG | Y | Also okay with the suggested addition from Ericsson. |
| CATT | Y | We can live with this for the sake of progress. |
| SONY6 | Y | Agree with Ericsson |
| Lenovo, Motorola Mobility | Y |  |
| vivo | N | The proposal regarding MIMO layer should be pending until the conclusion of Rx antenna is made. |
| NEC | Y |  |
| CMCC | N | The number of layers should equals with number of Rx branches. |
| ZTE | Y |  |
| OPPO | N | Agree with vivo we shall firstly wait for the result of the discussion on the number of supported Rx in FR2.  In addition, the number of the maximum MIMO layer shall be the same as the number of supported Rx. There is no clear motivation to support smaller maximum MIMO layer than the number of supported Rx. |
| Samsung | N | We think N=1 should be supported together with 1Rx as the **minimum** number of RX branches.  We should agreed on # of Rx first and then discuss whether more relax of MIMO layer is needed or not. |
| Sequans | Y\* | Maybe with minor modification, to be aligned with conclusion proposals on Rx branches:  *Recommend that the specification supports RedCap UEs with ~~max~~ 1 DL MIMO layer as well as RedCap UEs with ~~max~~ 2 DL MIMO layers for FR1 TDD bands where a non-RedCap UE is required to be equipped with a minimum of 4 Rx branches.* |
| Huawei, HiSilicon | FFS |  |
| Spreadtrum |  | Number of DL MIMO layers should be the same as the #Rx |
| FL | Based on received responses, the following proposal can be considered as a way forward.  **FL3: Phase 1: Proposal 12-82:**   * **For FR1 TDD bands where a non-RedCap UE is required to be equipped with a minimum of 4 Rx branches,**   + **For a RedCap UE with 1 Rx branch (if supported), the maximum number of DL MIMO layers is 1.**   + **For a RedCap UE with 2 Rx branches, the maximum number of DL MIMO layers is *M*.** **Down-select between the following options during RAN1#103e:**     - **Option A: *M*=1**     - **Option B: *M*=1, with *M*=2 as an optional capability**     - **Option C: *M*=2** | |
| Ericsson | Y | We prefer Option C. |
| vivo | Y | Prefer B |
| Samsung |  | We are OK for the proposal. For downselect for three options, we wupport Option C, M=2. |
| NEC | Y | Option B |
| CATT | Y | We prefer Option C. |
| CMCC | Y | Option C |
| DOCOMO | Y | We prefer Option B but can live with Option C |
| Xiaomi | Y | Option B |
| LG | Y | Option C |
| ZTE | Y | Option B |
| Nokia, NSB | Y | Option C |
| SONY | Y | Option B. We think that mandating 2RX antennas would effectively mean that FR1 FDD would also need to support 2RX antennas, which we would like to avoid. |
| FUTUREWEI4 | Y | Option C |
| Qualcomm | Y | Option C |
| MediaTek | Y | We prefer Option C |
| Intel | Y | Option B is preferred.  ***Also, what about teh cases of FR1 FDD bands with 4Rx requirement for non-RedCap UEs and FR1 TDD bands with 2Rx requirement for non-RedCap UEs?*** |
| Lenovo, Motorola Mobility | Y | Option C |
| Sierra Wireless | Y | Option C |

**Phase 1: Proposal 12-90: Support that the minimum number of supported DL MIMO layers of an FR2 RedCap UE is 1.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| CATT | Y | Also fine to wait for conclusions from cost evaluations of combinations. |
| LG | Y |  |
| ZTE | Y |  |
| vivo | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI | almost | 2RX/2MIMO layers also is supported by UE capability |
| Qualcomm | Y |  |
| DOCOMO | Y |  |
| InterDigital | Y |  |
| Sierra Wireless | Y |  |
| Samsung |  | No need to make recommendation for MIMO layer reduction itself. But OK with 1 Rx |
| Ericsson | Y |  |
| Sharp | Y |  |
| Intel | Y |  |
| Spreadtrum | Y |  |
| OPPO | Y |  |
| NEC | Y |  |
| Xiaomi | Y |  |
| FL | Based on received responses, the following proposal can be considered as a way forward.  **FL1: Phase 1: Proposal 12-91: Recommend that the specification supports RedCap UEs with max 1 DL MIMO layer as well as RedCap UEs with max 2 DL MIMO layers for FR2 bands where a non-RedCap UE is required to be equipped with a minimum of 2 Rx branches.** | |
| FUTUREWEI | Y | We can accept this for progress, though more discussion may be needed later on the relation of RX and layer (e.g., is 2RX always 2 layer, or can also be 1 layer) |
| MediaTek | N | DL MIMO layers reduction beyond the number of Rx branches shouldn’t be supported. |
| Ericsson | Y | We would also be fine to add a sub-bullet stating that the UE is not required to support a higher number of DL MIMO layers than the number of Rx branches, although it seems somewhat obvious. |
| Qualcomm |  | We suggest the following changes for this proposal:  *For FR2 bands where a non-RedCap UE is required to be equipped with a minimum of 2 Rx branches, recommend that the specification supports RedCap UEs with max 1 DL MIMO layer and 1 RX branch, as well as RedCap UEs with max 2 DL MIMO layers and 2 RX branches.* |
| Intel | Y |  |
| Nokia, NSB | N | As we don’t support 2Rx for FR2, we do not support 2 DL MIMO layers here. |
| DOCOMO | Y |  |
| LG | Y | Also okay with the suggested addition from Ericsson. |
| CATT | Y | We can live with this for the sake of progress. |
| Lenovo, Motorola Mobility | Y |  |
| vivo | N | First of all, no sure what is the intention to change the proposal from the previous one which has been supported by all companies.  Secondly, the proposal regarding MIMO layer should be pending until the conclusion of Rx antenna is made. |
| NEC | Y |  |
| ZTE | N | We cannot see the necessity to support two layers since one layer can meet the peak data requirement |
| OPPO | N | Agree with vivo we shall firstly wait for the result of the discussion on the number of supported Rx in FR2.  In addition, the number of the maximum MIMO layer shall be the same as the number of supported Rx. There is no clear motivation to support smaller maximum MIMO layer than the number of supported Rx. |
| Samsung | N | As we don’t support 2Rx for FR2, we do not support 2 DL MIMO layers here.  We should agreed on # of Rx first and then discuss whether more relax of MIMO layer is needed or not. |
| Sequans | Y\* | \*Same comment as for 4Rx case above:  *Recommend that the specification supports RedCap UEs with ~~max~~ 1 DL MIMO layer as well as RedCap UEs with ~~max~~ 2 DL MIMO layers for FR1 TDD bands where a non-RedCap UE is required to be equipped with a minimum of 2 Rx branches.* |
| Spreadtrum |  | Number of DL MIMO layers should be the same as the #Rx |
| FL | Based on received responses, the following proposal can be considered as a way forward.  **FL3: Phase 1: Proposal 12-92:**   * **For FR2 bands where a non-RedCap UE is required to be equipped with a minimum of 2 Rx branches,**   + **For a RedCap UE with 1 Rx branch (if supported), the maximum number of DL MIMO layers is 1.**   + **For a RedCap UE with 2 Rx branches (if supported), the maximum number of DL MIMO layers is *M*.** **Down-select between the following options during RAN1#103e:**     - **Option A: *M*=1**     - **Option B: *M*=1, with *M*=2 as an optional capability**     - **Option C: *M*=2** | |
| Ericsson | Y | We prefer Option A or B since Option C seems to be overkill from data rate requirement point of view for the targeted use cases. |
| vivo | Y | Prefer B |
| Samsung |  | We are OK for the proposal. For downselect for three options, we wupport Option C, M=2. |
| NEC | Y | Option B |
| CATT | Y | We prefer Option C. |
| CMCC | Y | Option C |
| DOCOMO | Y | Share the same view with Ericsson |
| Xiaomi | Y | Option B |
| LG | Y | Option B. Mostly M=2 suffices in terms of peak bit rate. M=2 can be supported optionally just in case. |
| ZTE | Y | Option A |
| Nokia, NSB | Y | Option C. Our preference is not to support 2Rx for FR2 bands. However, if 2 Rx is to be supported then we prefer also to have 2 DL MIMO layers. |
| FUTUREWEI4 | Y | Lean towards Opt C. The handling for FR2 could be different for FR1. |
| Qualcomm | Y | Option C |
| MediaTek | Y | We prefer Option C. |
| Intel | Y | Option A or B; same reason as mentioned by Ericsson. |
| Lenovo, Motorola Mobility | Y | Option C |

**Phase 1: Proposal 12-100: Recommend that HD-FDD type B is not supported for RedCap FR1 FDD UEs.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Huawei, HiSilicon | Y |  |
| CATT | Y |  |
| CMCC | Y |  |
| LG | N | We don’t think this proposal is not needed. For the HD-FDD, **Proposal 12-110** seems to be enough. |
| ZTE | Y |  |
| vivo | Y |  |
| Nokia, NSB | Y |  |
| SONY5 | Y | We think that HD-FDD Type A is more important than HD-FDD Type B. While we prefer a single HD-FDD type, we don’t have a big aversion to HD-FDD Type B. |
| FUTUREWEI | Y | This seems to be aligned with the vast majority of companies results and preference |
| Qualcomm | Y |  |
| DOCOMO | Y |  |
| Samsung | N | No need to make recommendation to not support HD-FDD type B |
| Ericsson | Y |  |
| Sharp | Y |  |
| Spreadtrum | Y |  |
| OPPO | Y |  |
| FL | Based on received responses, the following proposal can be considered.  **FL3: Phase 3: Proposal 12-100: Recommend that HD-FDD type B is not supported for RedCap FR1 FDD UEs.** | |
| Ericsson | Y |  |
| vivo | Y |  |
| Samsung |  | We still think no need to provide recommendation to not support something. |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| Xiaomi | Y |  |
| LG | N | Agree with Samsung. Prefer to focus only on what to recommend. |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| FUTUREWEI4 | Y | It is likely that some secondary techniques may need to get decided at RAN, so it is best to not recommend this one. |
| Qualcomm | Y |  |
| Intel | Y |  |
| Lenovo, Motorola Mobility | Y |  |

**Phase 1: Proposal 12-110: Recommend that HD-FDD type A is optionally supported for RedCap FR1 FDD UEs.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Huawei, HiSilicon | FFS | We have some questions for better understanding the cost saving of HD-FDD type A. Unless they are clarified, we don’t see clear benefits justifying the recommendation of Type A. It is not about different UE implementations, rather, there seems to be mis-calculation in most of others results that can significantly impact the observations for cost saving (see our comments regarding Duplexer v.s filters inside/outside the duplexer).  The performance in terms of coverage, capacity, and latency etc. shuld be clear for Type A, i.e. less than FD-HDD. Of course, similar to the doubled processing time, this can be minimized by network control.  The spec impact can be depending. Current spec only support HD operation for CA/DC/SUL case where an advanced UE is assumed. With redcued capability and introducing HD-FDD to single cell FDD band, new UE behavior such as partial canclation should be defined. This is not trivial since NR supports mini-slot based scheduling, unlike LTE subframe-based where canclation can be easier.  We think FD-FDD is at least supported/recommended. |
| CATT | Y | We are OK if type A HD-FDD is an optional feature. |
| LG | Y(Partially) | Do we need “optionally” in this proposal? Unless we can assume those proposals without “optionally” as “mandatory” or “not optional” now, it is suggested to remove the “optionally” in the proposal. |
| ZTE | Y |  |
| vivo |  | No strong view. Also fine with not recommend HD-FDD Type A |
| Nokia, NSB | Y |  |
| SONY5 | Y (partially) | Agree with LG. Do we need “optionally” at this stage?  There seems to be a high degree of agreement among companies, maybe with one outlier, that there is an RF cost saving of about 15% for HD-FDD. |
| FUTUREWEI | N | This is stronger than the last FLS proposal … optional means all the spec impacts will have to be worked on, perhaps at the expense of a feature that applies to all bands of interest. Can consider more if type B is clearly not recommended and the spec impacts are made clear and we see some of the recommendations for e.g. N1/N2, modulation, etc. |
| Qualcomm | Y (partially) | Agree with the comments of LG and Sony.  If a RedCap UE supports FD-FDD, it has no issue to support HD-FDD type A. Therefore, we don’t need to include “optional” here. HD-FDD type A should be supported as a mandatory instead of optional UE capability. |
| DOCOMO | Y |  |
| InterDigital | Y |  |
| Sierra Wireless | Y (partially) | Perhaps “optionally” is not needed at this stage.  The cost saving of HD-FDD for a real-world device that operates in multiple bands is significant. The single band analysis that is used in this study does not accurately reflect on this. The fact that HD-FDD results accumulate across bands on a multi-band device should not be lost.  For each FDD band, a FD-FDD device needs to have an expensive RF duplexer. Whereas with the HD-FDD a cheap switch can be used. This is one of the benefits of TDD, NB-IOT, and LTE-M.  As for the filter, from our analysis, if you use two separate components for the switch and low pass filter, the filter is around 1/10th of the price of the switch. If you use an integrated switch and filter part, the additional cost of filter is very insignificant. |
| Samsung | Y |  |
| Ericsson |  | No strong view. However, if HD-FDD type A is supported in the specification for RedCap UEs, then FD-FDD should also be supported in the specification for RedCap UEs, and then it is probably FD-FDD that should be considered the optional feature rather than HD-FDD type A (since gNB might have no choice but to treat the UE as a HD-FDD type A UE until the UE has reported its FD-FDD capability). |
| Sharp | Y |  |
| Intel | Y (partially) | Agree with LG and others that the current wording could be improved a bit in context of SI recomendations.  We propose to replace “is optionally supported” with “can be supported”, and then leave the optional/mandatory support details for the normative phase. |
| Spreadtrum | Y (partially) | Agree with LG |
| OPPO | Y | No strong views |
| Xiaomi | Y |  |
| FL | Based on received responses, the following proposal can be considered.  **FL3: Phase 3: Proposal 12-111: Recommend that HD-FDD type A and FD-FDD are supported by specification for an FR1 FDD RedCap UE.** | |
| Ericsson | Y | No strong view |
| vivo |  | We are also fine with not recommending HD-FDD type A. |
| CATT | Y | We can live with this for the sake of progress. |
| DOCOMO | Y |  |
| Xiaomi | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| SONY | Y | Agree with Sierra Wireless (above) that the cost savings for a multi-band HD-FDD device are significant, so the results that have been obtained for single-band devices only tell half the story. We think that there should be support for HD-FDD in the specifications. |
| FUTUREWEI4 | N | All the spec impacts will have to be worked on, perhaps at the expense of a feature that applies to all bands of interest. Can consider more if type B is clearly not recommended and the spec impacts are made clear and we see some of the recommendations for e.g. N1/N2, modulation, etc.  Most likely we will recognize that Half-duplex (type A), processing time, and modulation (DL) all have similar small gains and should be decided together at RAN where one or more are selected as a secondary technique after BW and antenna/MIMO. |
| Qualcomm | Y |  |
| Intel | Y |  |
| Lenovo, Motorola Mobility | Y |  |
| Sierra Wireless | Y | We do not see the need to decide these (Half-duplex, processing time, and modulation) as a package since they are not technically interrelated.  Also, since Half-duplex cost saving accumulate across bands (as agreed), when you consider a typical multi-band device, half duplex will provide more saving than what has been captured. |

**Phase 1: Question 12-120: Should the TR recommend relaxed UE processing time in terms of N1/N2 for RedCap UEs?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Huawei, HiSilicon | Y | It should be clear that the cost saving from doubled N1/N2 can be obvious based on different implementation (ours is 5.5% referring to reference UE, which is several $ for an IoT device!). It also has a benefit to be applicable to all FDD, TDD, FR1 and FR2. For the UE vendors do not want to implement this, capability#1 can be reused but certain choise for achieveing an even cheaper RedCap without penalty on network performance should be allowed.  The impact of doubled N1/N2 to network scheduler can be minimized by access control or early identification. Or can be comparable to the impact of other reduced capabilities, e.g. the potential support of 1Rx leads to many UEs without MIMO supported, the potential support of HD-FDD lead to TDD-like scheduling for a FDD network (which scheduler is different from TDD).  The spec impact of introducing doubled N1/N2 is expected to be small – introducing the new values only in sections for defining N1/N2 so other sections referring to N1/N2 can remain unchanged. |
| CATT | N | 1) No significant cost reduction in consensus.  2) At the cost of increasing the scheduling complexity of gNB, inevitably.  3) Have negative and complex impact on Msg2/3/4 scheduling, if RedCap UE cannot be identified early. |
| LG | Y |  |
| ZTE | Y |  |
| vivo | Y |  |
| Nokia, NSB | N | No meaningful cost reduction and there may be an impact to legacy UEs as the timing between RAR grant and Msg3 depends on N1 and N2 values |
| SONY5 | N | The cost saving doesn’t merit including this feature. |
| FUTUREWEI |  | This is a small reduction that can be discussed with several others that are similar. |
| Qualcomm | N |  |
| DOCOMO | N | Agree with CATT |
| InterDigital | Y |  |
| Sierra Wireless | FFS | The current analysis shows that N1/N2 only reduces cost by ~1.5% e.g.   * 20 MHz, 1 layer, 1 Rx, relaxed mods = 43.9% * 20 MHz, 1 layer, 1 Rx, relaxed mods, double N1/N2 = 42.4%   Only a single band UE was used for the study, but real-world devices all support multiple bands. And this cost saving does not multiply when more RF bands are added so when e.g. 20 bands are supported the % saving would be even smaller. |
| Samsung |  | Wait until the summary of combinations. |
| Ericsson | N | The relatively small potential cost reduction from relaxed N1/N2, especially when the technique is in a combination with other complexity reduction techniques that reduce the baseband complexity, does not seem to be worth the identified impacts on scheduling flexibility, etc. |
| Sharp | Y |  |
| Intel | Y | We support the recommendation.  On gNB scheduler complexity, considering we already have two timelines and many other separate margins and special cases, the effective impact to scheduler complexity compared to what it may need to handle already is unclear.  On RedCap UE identification, this may anyway be necessary for coverage purposes. Thus, the timing relaxation can be accommodated using the same framework, and there would be no adverse impact to legacy UE in terms of initial access.  On the gain margins, in isolation this technique offers similar (if not higher) gains w.r.t. reference UE as for some others (e.g., max modulation orders, within which DL and UL were coupled), and thus, should be considered similarly, not based on a particular order of consideration of the relaxations. |
| Spreadtrum | Y |  |
| OPPO | Y |  |
| FL | Based on received responses, the following proposal can be considered.  **FL3: Phase 3: Proposal 12-121: Recommend that relaxed UE processing time in terms of N1/N2 is supported by specification for a RedCap UE.** | |
| Ericsson | N | The relatively small potential cost reduction from relaxed N1/N2, especially when the technique is in a combination with other complexity reduction techniques that reduce the baseband complexity (in the order of 2% according to the tables in Section 7.8.2 in this document), does not seem to be worth the identified impacts on scheduling flexibility, etc. |
| vivo |  | We would be fine to not recommend it. |
| Samsung |  | We like to clarify that does this mean, one and only one UE processing time will be supported?  We agreed with Ericsson’ observation that the cost saving combining with BW reduction and Rx reduction would be too small. Therefore, we prefer to not recommend it. |
| CATT | N | Should not recommend relaxed processing time, if a tight scope is still targeting.  The most important reason is that the cost reduction of this feature is marginal. According to the evaluation results averaged from all companies, only ~2% cost reduction can be achieved when combined with the reduced BW and Rx antenna. Note that, this is the minimum cost reduction among all evaluated features, which is even smaller than HD-FDD and relaxed modulation order. It does not deserve more precious discussion time which should be spent in more important features, like Rx antenna number or BW after initial access in FR1.  We do not agree with comments that the impact to the network is small. Introducing a new relaxed processing capability will definitely increase the scheduling complexity from the network side. It will be more difficult for the gNB to perform proper scheduling, where the flexibility, efficiency, and more importantly the fairness among 3 different capability UEs are need to be taken into consideration. |
| DOCOMO | N |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB | N | The cost reduction in combination with other techniques is too small to justify recommending N1/N2 relaxation. |
| SONY | N | Cost saving not significant. |
| FUTUREWEI4 |  | Most likely we will recognize that Half-duplex (type A), processing time, and modulation (DL) all have similar small gains and should be decided together at RAN where one or more are selected as a secondary technique after BW and antenna/MIMO. |
| Qualcomm | N | Agree with Ercisson, Samsung and CATT |
| Intel | Y | We support the recommendation.  We already provided technical justfications. Once again, teh point about “two to three timelines” is grossly inaccurate – the gNB has to handle many different timelines already due to numerous special handling and margins defined in Rel-15 and Rel-16. So, the relative complexity increase would be limited in practice. |
| Lenovo, Motorola Mobility | Y |  |
| Sierra Wireless | N | No for the same reasons we already mentioned above in phase 1.  Agree with Ercisson, Sony, Nokia, Docomo, Qualcomm, Samsung and CATT |

**Phase 1: Question 12-130: Should the TR recommend relaxed maximum mandatory DL modulation (from 256QAM to 64QAM) for FR1 RedCap UEs?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Huawei, HiSilicon | Y |  |
| CATT | Y | About 6% cost reduction can be achieved (evaluated individually), and the highest required DL data rate can still be fulfilled. |
| CMCC | Y |  |
| ZTE | Y | No need to support 256QAM |
| vivo | Y |  |
| Nokia, NSB | N | Small cost reduction and some impact to efficiency (~6.4% reduction in spectral efficiency based on our analysis) |
| SONY | N | The cost saving doesn’t merit including this feature. |
| FUTUREWEI |  | This is a small reduction that can be discussed with several others that are similar.  The proposal should be to recommend that 256QAM DL is optional instead of mandatory. (If you already supported 256QAM efficiently in your chipset you should be able to keep supporting.) |
| Qualcomm | Y |  |
| DOCOMO | Y |  |
| InterDigital | Y |  |
| Sierra Wireless | Y |  |
| Samsung | Y |  |
| Ericsson | Y |  |
| Sharp | Y |  |
| Intel | Y |  |
| Spreadtrum | Y |  |
| OPPO | Y |  |
| NEC | Y |  |
| LG | Y |  |
| FL | Based on received responses, the following proposal can be considered.  **FL3: Phase 3: Proposal 12-131: Recommend that relaxed maximum mandatory DL modulation (from 256QAM to 64QAM) is supported by specification for an FR1 RedCap UE.** | |
| Ericsson | Y |  |
| vivo | Y |  |
| Samsung | Y |  |
| NEC | Y |  |
| CATT | Y |  |
| CMCC | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| ZTE | Y |  |
| Nokia, NSB |  | We still have a concern that the cost saving in combination with other techniques is too small while the impact to system efficiency is not small. |
| SONY |  | We don’t object to this feature (hence we do not write “N” in the column to the left). We just think it doesn’t provide that significant a cost saving. Hence neutral. |
| FUTUREWEI4 | If without optimization | The proposal should be to recommend that 256QAM DL is optional instead of mandatory. (If you already supported 256QAM efficiently you should be able to keep supporting.)  Most likely we will recognize that Half-duplex (type A), processing time, and modulation (DL) all have similar small gains and should be decided together at RAN where one or more are selected as a secondary technique after BW and antenna/MIMO. |
| Qualcomm | Y |  |
| Lenovo, Motorola Mobility | Y |  |
| Sierra Wireless | Y |  |

**Phase 1: Question 12-140: Should the TR recommend relaxed maximum mandatory UL modulation (from 64QAM to 16QAM) for FR1 RedCap UEs?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Huawei, HiSilicon | N |  |
| CATT | N | We do not want to make the RedCap UE even weaker than a legacy LTE UE, which has already mandatorily support 64QAM in UL. This is against the SID direction.  Only 1~2% cost reduction can be achieved (evaluated individually), and has significant negative impact on UL SE. |
| CMCC | N | Same view as CATT |
| ZTE | Y |  |
| vivo | Y | To respond CATT, 64QAM for UL was a very late feature even for LTE, RAN4 requirement was defined late. Therefore there are many LTE UEs actually not supporting 64QAM in UL |
| Nokia, NSB | N | Very small cost reduction and significant impact to efficiency (~23.6% reduction in spectral efficiency based on our analysis) |
| SONY | N | The cost saving doesn’t merit including this feature. |
| FUTUREWEI | N |  |
| Qualcomm | Y |  |
| DOCOMO | N | Agree with CATT |
| InterDigital | N |  |
| Sierra Wireless | Y | Only a single band UE was used for the study, but real-world devices all support multiple bands. And this cost saving DOES multiply when more RF bands are added so when e.g. 20 bands are supported the % saving would be great then the 1-2% the current evaluation is indicating. |
| Samsung | Y |  |
| Ericsson |  | No strong view. We are fine with or without relaxed maximum mandatory UL modulation. |
| Sharp | N | Agree with CATT. No significant reduction. As even in individual evaluation, there is roughly 2% reduction. In addition, it would also impact the current usage of MCS table for uplink. |
| Intel | N |  |
| Spreadtrum | Y |  |
| OPPO | Y | There is cost reduction. And the spec. impact is expected to be minor. |
| FL | Based on received responses, the following proposal can be considered.  **FL3: Phase 3: Proposal 12-141: Recommend that relaxed maximum mandatory UL modulation (from 64QAM to 16QAM) is not supported by specification for an FR1 RedCap UE.** | |
| Ericsson |  | No strong view |
| vivo | N | it should be supported |
| Samsung |  | We support relaxed mandatory UL modulation |
| NEC |  | No strong view but OK to support 16QAM as it is same as LTE Cat.4 |
| CATT | Y | Not worthy to sacrifice large UL SE but achieve marginal cost reduction gain (<1%) in return. |
| CMCC | Y | The average estimated cost reduction achieved by relaxing the maximum UL modulation order from 64QAM to 16QAM is ~2% for FR1 FDD, FR1 TDD, and FR2. However, 16QAM can only support 10.6Mbps peak data rate for TDD with DDDDDDDSUU, 64QAM is better. |
| DOCOMO | Y |  |
| LG |  | No strong view |
| ZTE | N | 64QAM could be an optional capability for FR1 UL for RedCap UE |
| Nokia, NSB | Y |  |
| FUTUREWEI4 | Y |  |
| Qualcomm | N | 16QAM sould be supported as the relaxed UL modulation order mandatory for RedCap UE. 64QAM can be supported as an optional UE capability for UL. |
| Intel | Y |  |
| Lenovo, Motorola Mobility | Y |  |
| Sierra Wireless | N | This cost reduction technique accumulates across bands so the cost saving will be much higher than indicated by the study. 64QAM can be supported as an optional UE capability for UL. This will not materially complicate or degrade efficiency of initial access. |

**Phase 1: Question 12-150: Should the TR recommend relaxed maximum mandatory DL modulation (from 64QAM to 16QAM) for FR2 RedCap UEs?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Huawei, HiSilicon | N |  |
| CATT | N | It is justified for the network to schedule RedCap UE with 64QAM when the SINR is high, to guarantee the DL SE. |
| CMCC | N |  |
| ZTE | Y | 16QAM is mandatory and 64QAM could be optional. |
| vivo | Y |  |
| Nokia, NSB | N |  |
| SONY | N | The cost saving doesn’t merit including this feature. |
| FUTUREWEI |  | The recommendation should be 64QAM is optional instead of mandatory. |
| Qualcomm | N |  |
| DOCOMO | N |  |
| InterDigital | N |  |
| Samsung | Y |  |
| Ericsson |  | No strong view |
| Sharp | N |  |
| Intel | N |  |
| OPPO | Y |  |
| FL | Based on received responses, the following proposal can be considered.  **FL3: Phase 3: Proposal 12-151: Recommend that relaxed maximum mandatory DL modulation (from 64QAM to 16QAM) is not supported by specification for an FR2 RedCap UE.** | |
| Ericsson |  | No strong view |
| vivo |  | Prefer to support it |
| Samsung |  | We support relaxed mandatory modulation for FR2 |
| CATT | Y |  |
| DOCOMO | Y |  |
| ZTE | N | 16QAM is sufficient for DL data rate. 64QAM should be an optional capability for FR2 DL for RedCap UE |
| Nokia, NSB | Y |  |
| FUTUREWEI4 |  | No strong view  If supported, no optimzations and the should be to recommend that 64QAM DL is optional instead of mandatory. (If you already supported 64QAM efficiently you should be able to keep supporting.) |
| Qualcomm | Y |  |
| Intel | Y |  |
| Lenovo, Motorola Mobility | Y |  |

**Phase 1: Question 12-160: Should the TR recommend relaxed maximum mandatory UL modulation (from 64QAM to 16QAM) for FR2 RedCap UEs?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments or suggested revisions** |
| Huawei, HiSilicon | N |  |
| CATT | N | It is justified for the network to schedule RedCap UE with 64QAM when the SINR is high, to guarantee the UL SE. In addition, the cost reduction of UL modulation order relaxation is too small (1~2% by indivitually evaluation). |
| CMCC | N |  |
| ZTE | Y |  |
| vivo | Y |  |
| Nokia, NSB | N |  |
| SONY | N | The cost saving doesn’t merit including this feature. |
| FUTUREWEI | N |  |
| Qualcomm | N |  |
| DOCOMO | N |  |
| InterDigital | N |  |
| Samsung | Y |  |
| Ericsson |  | No strong view. We are fine with or without relaxed maximum mandatory UL modulation. |
| Sharp | N |  |
| Intel | N |  |
| OPPO | Y | There is cost reduction. And the spec. impact is expected to be minor. |
| FL | Based on received responses, the following proposal can be considered.  **FL3: Phase 3: Proposal 12-161: Recommend that relaxed maximum mandatory UL modulation (from 64QAM to 16QAM) is not supported by specification for an FR2 RedCap UE.** | |
| Ericsson |  | No strong view |
| vivo |  | Prefer to support it |
| Samsung |  | We support relaxed mandatory modulation for FR2 |
| CATT | Y | Not worthy to sacrifice large UL SE but achieve marginal cost reduction gain (<1%) in return. |
| DOCOMO | Y |  |
| ZTE | N |  |
| Nokia, NSB | Y |  |
| FUTUREWEI4 | Y |  |
| Qualcomm | Y |  |
| Intel | Y |  |
| Lenovo, Motorola Mobility | Y |  |

# References

|  |  |  |  |
| --- | --- | --- | --- |
| [1] | [R1-2008837](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2008837.zip) | Potential UE complexity reduction features for RedCap (revision of [R1-2007529](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2007529.zip)) | Ericsson |
| [2] | [R1-2007534](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2007534.zip) | Complexity reduction features for RedCap UEs | FUTUREWEI |
| [3] | [R1-2009318](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2009318.zip) | Potential UE complexity reduction features (revision of [R1-2007596](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2007596.zip)) | Huawei, HiSilicon |
| [4] | [R1-2009212](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009212.zip) | Complexity reduction for Reduced Capability NR devices (revision of [R1-2007668](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2007668.zip)) | vivo, Guangdong Genius |
| [5] | [R1-2007715](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2007715.zip) | Potential UE complexity reduction features | ZTE |
| [6] | [R1-2007862](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2007862.zip) | Discussion on UE complexity reduction features | CATT |
| [7] | [R1-2007887](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2007887.zip) | Potential UE complexity reduction features | TCL Communication Ltd. |
| [8] | [R1-2009025](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009025.zip) | On potential UE complexity reduction features for RedCap (revision of [R1-2007947](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2007947.zip)) | Intel Corporation |
| [9] | [R1-2008016](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008016.zip) | Discussion on UE complexity reduction features | CMCC |
| [10] | [R1-2008048](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008048.zip) | Discussion on potential UE complexity reduction features | LG Electronics |
| [11] | [R1-2008068](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008068.zip) | UE complexity reduction features | Nokia, Nokia Shanghai Bell |
| [12] | [R1-2008857](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008857.zip) | Discussion on the complexity reduction for reduced capability device (revision of [R1-2008084](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008084.zip)) | Xiaomi |
| [13] | [R1-2008100](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008100.zip) | Discussion on potential UE complexity reduction features | Spreadtrum Communications |
| [14] | [R1-2008114](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008114.zip) | Discussion on bandwidth related features for RedCap devices | NEC |
| [15] | [R1-2008875](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008875.zip) | UE complexity reduction (revision of [R1-2008170](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008170.zip)) | Samsung |
| [16] | [R1-2008260](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008260.zip) | Discussion on UE complexity reduction | OPPO |
| [17] | [R1-2008294](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008294.zip) | UE complexity reduction features for RedCap | Lenovo, Motorola Mobility |
| [18] | [R1-2008315](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008315.zip) | Reduced Capability UE Complexity Reduction Features | Sierra Wireless, S.A. |
| [19] | [R1-2008366](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008366.zip) | On potential complexity reduction techniques for NR devices | Sony |
| [20] | [R1-2008382](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008382.zip) | Discussion on potential UE complexity reduction features | Panasonic Corporation |
| [21] | [R1-2008394](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008394.zip) | Discussion on Potential UE complexity reduction features | Sharp |
| [22] | [R1-2008469](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008469.zip) | Potential UE complexity reduction features for RedCap | Apple |
| [23] | [R1-2009543](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2009543.zip) | On complexity reduction features for NR RedCap UEs (revision of [R1-2008510](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008510.zip)) | MediaTek Inc. |
| [24] | [R1-2008551](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008551.zip) | Discussion on potential UE complexity reduction features for RedCap | NTT DOCOMO, INC. |
| [25] | [R1-2008581](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008581.zip) | Discussion on potential UE complexity reduction features | ASUSTeK |
| [26] | [R1-2008620](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008620.zip) | Complexity Reduction for RedCap Devices | Qualcomm Incorporated |
| [27] | [R1-2008684](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008684.zip) | UE complexity reduction features for reduced capability NR devices | InterDigital, Inc. |
| [28] | [R1-2008738](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008738.zip) | Complexity reduction features for RedCap UE | Sequans Communications |
| [29] | [R1-2007599](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2007599.zip) | Framework and principles for reduced capability devices | Huawei, HiSilicon |
| [30] | [R1-2007671](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2007671.zip) | Framework and Principles for Reduced Capability NR devices | vivo, Guangdong Genius |
| [31] | [R1-2008019](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008019.zip) | Discussion on design principles and definition for RedCap device type | CMCC |
| [32] | [R1-2008101](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008101.zip) | Discussion on Framework and Principles for Reduced Capability | Spreadtrum Communications |
| [33] | [R1-2008623](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008623.zip) | Standardization Framework and Design Principles for NR RedCap Devices | Qualcomm Incorporated |
| [34] | [R1-2008741](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Docs/R1-2008741.zip) | Framework and principles for RedCap UE | Sequans Communications |
| [35] | [R1-2007482](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2007482.zip) | FL summary on initial collection of RedCap evaluation results | Moderator (Ericsson, Apple, Qualcomm) |
| [36] | [RP-201677](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_89e/Docs/RP-201677.zip) | Revised SID on Study on support of reduced capability NR devices | Ericsson |
| [37] | [RP-201676](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_89e/Docs/RP-201676.zip) | SR for Study on support of reduced capability NR devices | Ericsson |
| [38] | [R1-2007476](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2007476.zip) | FL summary #1 for RedCap evaluation templates | Moderator (Ericsson, Apple, Qualcomm) |