**3GPP TSG RAN WG1 #103-e R1-200xxxx**

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

**Agenda item:** 8.6.3

**Source:** Moderator (Qualcomm Inc.)

**Title:** FL summary #5 on Coverage Recovery and Capacity Impact for RedCap

**Document for:** Discussion and Decision

# Introduction

This contribution summarizes the contributions submitted to AI 8.6.3 (Study on NR reduced capability devices – coverage recovery and capacity impact).

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

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| [103-e-NR-RedCap-04] Email discussion for coverage recovery and capacity impact– Chao (Qualcomm)   * 1st check point: 10/29 * 2nd check point: 11/4 * 3rd check point: 11/10 * Last check point 11/12 |

In this round of the email discussion, please check the proposals/questions tagged ‘FL5’ (search for ‘FL5’).

# Target Performance Requirement

**[FL5]** The only remaining issue is how to address the FFS part in the following agreement made in the 11/5 online (GTW) session:

|  |
| --- |
| Agreements:   * Agree in principle using Option 3 for determining the coverage recovery target   + Option 3: The coverage recovery target for each channel of RedCap UE corresponds to the link budget of the bottleneck channel(s) for the reference NR UE within the same deployment scenario   + Note: The reference UE is a Rel-15/16 NR UE with mandatory features only * FFS For Option 3, companies report their individual observations of the amount of compensation for each channel by comparing the link budget with that of the bottleneck channel for the reference NR UE (i.e. the LB of the channel for RedCap UE – the LB of the bottleneck channel for the reference UE)   + A representative value of the amount of compensation is derived by taking the mean value (in dB domain) from all the compensation values including both negative and non-negative values     - Excluding the highest & the lowest values when the number of samples is more than 3     - If the number of samples used to compute a representative value is less than 4 for each scenario, this representative value is not used for bottleneck identification     - In this case, observations may still be drawn   + The representative value of a channel is used for identifying whether the channel needs coverage recovery     - Coverage recovery is not needed if the representative value of a channel is larger than or equal to zero |

The FL’s understanding is there are possible two approaches for deriving representative value. The first is to follow the approach used in the Rel-17 CE SI. That is, for each channel of the reference NR UE, we calculate a mean value of the MIL performance from all the companies results by excluding the highest & lowest values and find the channel with the lowest mean MIL value as the bottleneck channel. Then, for each channel of RedCap UE we compare the MIL performance to the mean MIL of the bottleneck channel and derive a representative value of the coverage difference.

The second approach is what is described in the FFS part of the agreement. Compared to the first approach, the bottleneck channel for the reference NR UE by sourcing companies is not necessary to be aligned. Companies could report their individual observations of the bottleneck channel for the reference NR UE and compare the MIL of each RedCap UE channel with that of the bottleneck channel for deriving a representative value of the coverage difference.

According to the email discussion, when the same observation of the bottleneck channel for the reference NR UE is reported by companies, the difference between the two approaches will be minor. When the observations of the bottleneck channel for the reference NR UE are different among companies, the first approach may give a relatively larger value for amount of coverage loss for RedCap UE. In the following we will use one example for further explanation.

As discussed, for the first approach we need to firstly determine the bottleneck channel for the reference NR UE, i.e. the channel with the lowest mean MIL value. As seen from Table 2-1, for indoor 28 GHz, the bottleneck channel is PDSCH and the mean MIL is 138.8 dB. However, as seen from Table 2-2, based on the individual observation by each company, the bottleneck channel for the reference NR UE is very diverse. Only A few companies (i.e. 2 out of 10) report PDSCH is the bottleneck.

**Table 2-1: Mean MIL loss (dB) for Ref NR UE in Indoor 28 GHz (Approach #1)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22 bits | PUSCH | Msg3 | PRACH |
| Mean MIL (dB) | 142.5 | 144.0 | 138.8 | 141.7 | 140.9 | 141.1 | 159.0 | 156.7 | 155.1 | 139.1 | 152.4 | 152.5 |

**Table 2-3: Bottleneck channel and MIL for Ref NR UE in Indoor 28 GHz (Approach #2)**

|  |  |  |
| --- | --- | --- |
|  | Bottleneck channel | MIL |
| Samsung | PUSCH | 133.3 |
| ZTE | PUSCH | 134.3 |
| OPPO | PUSCH | 141.9 |
| vivo | PUSCH | 131.4 |
| Nokia | PDSCH | 139.3 |
| DCM | Msg4 | 142.0 |
| Ericsson | Msg4 | 128.0 |
| IDCC | Msg4 | 142.5 |
| QC | PUSCH | 138.8 |
| Intel | PDSCH | 132.1 |

We compare the MIL of each RedCap UE channel to the target performance (i.e. 138.8 dB for Approach #1 and the MIL value in Table 2-3 for Approach #2) and the results are shown in Table 2-3 and 2-4 for Approach #1 and 2, respectively.

**Table 2-3: Coverage loss (dB) for 1Rx/100MHz RedCap UE in Indoor 28 GHz (Approach #1)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22 bits | PUSCH | Msg3 | PRACH |
| Samsung | 3.5 | 3.6 | -2.4 | 0.7 | -1.6 |  | 18.7 | 15.1 | 11.6 | -5.5 | 10.6 |  |
| ZTE | -2.3 | -1.6 | -9.6 | -4.7 | -4.1 |  | 18.7 | 14.3 | 13.5 | -4.5 | 13.5 |  |
| OPPO | 2.2 | 2.2 | 0.0 | 1.3 | 0.6 |  | 21.2 | 20.9 | 21.2 | 3.1 | 21.4 |  |
| vivo | -7.0 | -2.0 | -8.0 | -11.5 | -8.3 | -4.5 | 15.1 | 13.5 | 10.2 | -7.4 | 4.0 | 3.8 |
| Nokia | 0.7 | 0.5 | -2.8 | 3.7 | 2.7 |  | 21.7 |  | 20.1 | 6.1 | 14.3 | 18.7 |
| DCM | 6.1 | 6.1 | -0.4 | -1.7 | -1.8 |  | 19.8 | 25.2 |  | 8.5 | 21.5 |  |
| Ericsson | -10.6 | -9.6 | -14.4 | -14.0 | -15.3 | -8.2 | 11.7 | 11.7 | 9.3 | -0.1 | 7.5 | 10.3 |
| IDCC | 4.7 | 4.7 | -0.2 | -0.8 | -0.9 |  | 27.5 |  | 21.9 | 4.6 | 20.6 |  |
| QC | 1.3 | 7.3 | -1.1 | -0.3 | 5.0 | 10.9 | 32.0 | 25.9 | 23.4 | 0.0 | 8.6 | 24.6 |
| Intel | -3.7 | -2.9 | -10.8 | -1.7 | -4.8 | -1.0 | 18.2 | 18.5 | 15.4 | -1.4 | 12.1 | 12.1 |
| Representative value (dB) | **-0.1** | **1.3** | **-4.4** | **-2.3** | **-2.3** | **-2.8** | **20.1** | **17.9** | **16.3** | **0.3** | **13.6** | **13.7** |

**Table 2-4: Coverage loss (dB) for 1Rx/100MHz RedCap UE in Indoor 28 GHz (Approach #2)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22 bits | PUSCH | Msg3 | PRACH |
| Samsung | 9.0 | 9.1 | 3.1 | 6.2 | 3.9 |  | 24.2 | 20.6 | 17.1 | 0.0 | 16.1 |  |
| ZTE | 2.1 | 2.8 | -5.2 | -0.2 | 0.3 |  | 23.1 | 18.8 | 18.0 | 0.0 | 18.0 |  |
| OPPO | -0.9 | -0.9 | -3.1 | -1.7 | -2.5 |  | 18.2 | 17.8 | 18.1 | 0.0 | 18.4 |  |
| vivo | 0.4 | 5.4 | -0.6 | -4.0 | -0.8 | 2.9 | 22.6 | 20.9 | 17.6 | 0.0 | 11.4 | 11.2 |
| Nokia | 0.3 | 0.0 | -3.3 | 3.2 | 2.2 |  | 21.2 |  | 19.6 | 5.6 | 13.8 | 18.2 |
| DCM | 2.9 | 2.9 | -3.5 | -4.8 | -5.0 |  | 16.6 | 22.0 |  | 5.4 | 18.3 |  |
| Ericsson | 0.2 | 1.2 | -3.6 | -5.6 | -4.5 | 2.6 | 22.5 | 22.6 | 20.1 | 10.7 | 18.3 | 21.1 |
| IDCC | 1.0 | 1.0 | -3.9 | -4.5 | -4.6 |  | 23.8 |  | 18.2 | 0.9 | 16.9 |  |
| QC | 1.3 | 7.3 | -1.2 | -0.4 | 5.0 | 10.8 | 32.0 | 25.8 | 23.3 | 0.0 | 8.6 | 24.6 |
| Intel | 3.0 | 3.8 | -4.1 | 5.0 | 1.9 | 5.7 | 24.9 | 25.2 | 22.1 | 5.3 | 18.8 | 18.7 |
| Representative value (dB) | **1.4** | **3.0** | **-2.9** | **-0.9** | **-0.5** | **4.3** | **22.6** | **21.7** | **19.1** | **2.2** | **16.4** | **19.3** |

By comparing Table 2-3 to Table 2-4, it can be observed that Approach #1 may give a large estimate of potential coverage loss for RedCap UE, e.g. 1-2 dB more. Also, Approach #1 may indicate some channels that may not be needed for compensation having to compensate. For example, PBCH is assumed for coverage recovery based on Approach #1, but not needed for Approach #2.

The large fluctuation by Approach #1 may be caused by different assumption of antenna array gain correction factors by each company and an absolute target performance by averaging over all the companies results seems not a good metric to evaluate the coverage loss for RedCap UE. Approach #2 allow companies to individually calculate the performance difference between RedCap and the reference NR UE and the use of the representative value can further remove some outlies to avoid having to compensate to channel that may not need compensation.

Therefore, the FL suggestion is to use Approach #2 for deriving the representative value for Option 3.

**[FL5] Proposal 2-1:**

* For Option 3, companies report their individual observations of the amount of compensation for each channel by comparing the link budget with that of the bottleneck channel for the reference NR UE (i.e. the LB of the channel for RedCap UE – the LB of the bottleneck channel for the reference UE)
  + A representative value of the amount of compensation is derived by taking the mean value (in dB domain) from all the compensation values including both negative and non-negative values
    - Excluding the highest & the lowest values when the number of samples is more than 3
    - If the number of samples used to compute a representative value is less than 4 for each scenario, this representative value is not used for bottleneck identification
    - In this case, observations may still be drawn
  + The representative value of a channel is used for identifying whether the channel needs coverage recovery
    - Coverage recovery is not needed if the representative value of a channel is larger than or equal to zero

**[FL5] Question 2-1:** **Can the above proposal be agreed? If not, please provide technical justification**.

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Panasonic | Y | We support approach#2 as it is straightforward. In addition, for the next step, there could be controversial between companies to determine how much dB to compensate the coverage loss due to different values derived from approach#1 and approach#2. A compromise solution for each channel could be expressed as the presentative value derived in approach#2 + X dB, where X can be 1 or 2 dB selected up to RAN1 group discussion. |
| vivo |  | No strong position between approach#1 and approach#2, maybe approach#2 could make sense since the impact due to different detailed assumptions might be mitigated.  However, we still have concern to solely based on Option 3 to determine the coverage compensation for FR2 indoor scenario. Even though we did not agree to option 1, but at least we should keep in mind what will be targeting scenario when making the decision. We would like to avoid the case that some channel are recommended for coverage compensation but actually no real coverage issue in the filed deployment, i.e. overcompensation.  Our analysis on FR2 indoor scenario is shown in the figure below, it can be seen that no coverage compensation for RedCap UEs is needed even if we target up to 100m ISD, however, coverage compensation is required if the decision is solely made based on option 3.  cid:image002.png@01D6B6B1.B14EB3C0 |
|  |  |  |

# Coverage Recovery

## FR1, Urban with the carrier frequency of 2.6 GHz

Based on the latest available evaluation results in [RedCapCoverage-2.6GHz-v019-Panasonic.xlsx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/drafts/8.6/EvaluationResults/RedCapCoverage/2.6GHz/RedCapCoverage-2.6GHz-v019-Panasonic.xlsx), the link budget performance for both the reference UE and RedCap UE in Urban scenario at 2.6GHz is summarized in Table 3.1-1 to Table 3.1-3 (Company please double check whether your results are correctly captured in these tables. I have found there are some mismatch between the spreadsheet and the contribution for some companies results).

In the link budget tables, the maximum isotropic loss (MIL) is used as the coverage evaluation metric and for each channel the margin to the target performance is also shown, where the target performance is a company specific value and derived based on the link budget of the bottleneck channel for the reference NR UE (i.e. Option 3). The coverage limiting channel for RedCap UE, e.g. the link budget for the channel worse than that target performance, is highlighted with RED.

**Table 3.1-1: Link budget performance for the reference NR UE (100MHz BW, 4Rx)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Urban 2.6GHz, 4Rx Reference UE** | | | | | | | | | | | | | | |
|  |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22bits | PUSCH | Msg3 | PRACH | Target /Option3 |
| Samsung | MIL (dB) | 165.9 | 170.1 | 163.6 | 162.3 | 162.4 |  | 158.6 | 154.8 | 151.8 | 139.4 | 150.0 |  | 139.4 |
| Margin (dB) | 26.4 | 30.6 | 24.1 | 22.8 | 22.9 |  | 19.2 | 15.4 | 12.4 | 0.0 | 10.6 |  |  |
| ZTE | MIL (dB) | 157.0 | 167.4 | 167.6 | 157.7 | 158.0 |  | 162.6 | 160.9 | 158.4 | 142.0 | 156.5 |  | 142.0 |
| Margin (dB) | 15.0 | 25.4 | 25.7 | 15.7 | 16.0 |  | 20.7 | 18.9 | 16.4 | 0.0 | 14.5 |  |  |
| OPPO | MIL (dB) | 167.5 | 171.5 | 169.9 | 162.2 | 165.2 |  | 155.0 | 155.1 | 155.2 | 145.1 | 154.7 |  | 145.1 |
| Margin (dB) | 22.3 | 26.3 | 24.8 | 17.1 | 20.1 |  | 9.9 | 9.9 | 10.1 | 0.0 | 9.6 |  |  |
| CATT | MIL (dB) | 164.7 | 168.7 | 167.6 | 161.5 | 163.8 |  | 160.3 | 158.9 | 156.9 | 145.9 | 153.5 |  | 145.9 |
| Margin (dB) | 18.7 | 22.7 | 21.6 | 15.5 | 17.8 |  | 14.4 | 12.9 | 10.9 | 0.0 | 7.6 |  |  |
| vivo | MIL (dB) | 157.6 | 165.6 | 162.0 | 157.1 | 158.6 | 160.8 | 156.2 | 153.6 | 151.1 | 137.8 | 152.5 | 149.7 | 137.8 |
| Margin (dB) | 19.8 | 27.8 | 24.2 | 19.4 | 20.9 | 23.0 | 18.4 | 15.9 | 13.3 | 0.0 | 14.7 | 11.9 |  |
| Xiaomi | MIL (dB) | 166.3 | 166.3 | 168.4 | 162.9 | 165.3 |  | 161.6 | 158.9 | 157.2 | 146.7 | 154.6 |  | 146.7 |
| Margin (dB) | 19.5 | 19.5 | 21.6 | 16.1 | 18.5 |  | 14.9 | 12.2 | 10.5 | 0.0 | 7.9 |  |  |
| Futurewei | MIL (dB) | 164.8 | 166.8 | 164.3 | 162.8 | 163.2 |  |  |  |  | 151.6 | 153.5 |  | 151.6 |
| Margin (dB) | 13.1 | 15.1 | 12.6 | 11.1 | 11.5 |  |  |  |  | 0.0 | 1.9 |  |  |
| Nokia | MIL (dB) | 168.3 | 168.3 | 166.8 | 167.3 | 165.8 |  | 151.7 |  | 150.2 | 138.6 | 147.8 | 150.3 | 138.6 |
| Margin (dB) | 29.7 | 29.7 | 28.2 | 28.7 | 27.2 |  | 13.1 |  | 11.6 | 0.0 | 9.2 | 11.7 |  |
| DOCOMO | MIL (dB) | 165.6 | 169.6 | 166.2 | 160.5 | 162.6 |  | 161.1 | 164.9 |  | 145.7 | 154.6 |  | 145.7 |
| Margin (dB) | 19.9 | 23.9 | 20.4 | 14.7 | 16.9 |  | 15.4 | 19.2 |  | 0.0 | 8.9 |  |  |
| CMCC | MIL (dB) | 162.8 | 168.4 | 166.7 | 160.8 | 163.4 | 163.8 | 156.3 | 154.5 | 152.3 | 139.8 | 152.8 | 158.6 | 139.8 |
| Margin (dB) | 23.0 | 28.6 | 26.9 | 21.0 | 23.6 | 24.1 | 16.5 | 14.7 | 12.6 | 0.0 | 13.1 | 18.9 |  |
| Panasonic | MIL (dB) |  | 169.0 | 161.0 |  |  |  |  |  |  |  |  |  |  |
| Margin (dB) |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Huawei | MIL (dB) | 164.0 | 168.0 | 164.2 | 161.1 | 160.9 |  | 160.6 |  | 158.3 | 139.0 | 149.6 |  | 139.0 |
| Margin (dB) | 25.0 | 29.0 | 25.3 | 22.1 | 21.9 |  | 21.6 |  | 19.3 | 0.0 | 10.7 |  |  |
| Spreadtrum | MIL (dB) | 165.0 | 169.0 | 166.9 | 163.8 | 163.8 | 166.3 | 158.4 | 156.6 | 156.2 | 145.7 | 153.5 | 155.8 | 145.7 |
| Margin (dB) | 19.3 | 23.3 | 21.2 | 18.1 | 18.1 | 20.6 | 12.7 | 10.9 | 10.5 | 0.0 | 7.8 | 10.1 |  |
| Apple | MIL (dB) | 160.5 | 168.5 | 163.9 | 153.8 | 157.0 |  |  |  | 150.8 | 140.0 | 144.7 |  | 140.0 |
| Margin (dB) | 20.5 | 28.5 | 23.9 | 13.8 | 17.0 |  |  |  | 10.8 | 0.0 | 4.8 |  |  |
| Ericsson | MIL (dB) | 162.0 | 162.0 | 162.5 | 156.9 | 159.4 | 163.8 | 154.8 | 155.5 | 153.6 | 143.9 | 151.2 | 155.1 | 143.9 |
| Margin (dB) | 18.0 | 18.0 | 18.5 | 12.9 | 15.4 | 19.8 | 10.9 | 11.6 | 9.6 | 0.0 | 7.3 | 11.1 |  |
| InterDigital | MIL (dB) | 164.47 | 168.47 | 166.15 | 160.47 | 162.55 |  | 160.6 |  | 156.4 | 143.24 | 152.84 |  | 143.24 |
| Margin (dB) | 21.23 | 25.23 | 22.91 | 17.23 | 19.31 |  | 17.36 |  | 13.16 | 0.0 | 9.6 |  |  |
| Qualcomm | MIL (dB) | 161.3 |  | 163.4 | 158.3 | 159.8 |  |  |  | 146.5 | 139.4 | 148.2 |  | 139.4 |
| Margin (dB) | 22.0 |  | 24.0 | 18.9 | 20.4 |  |  |  | 7.2 | 0.0 | 8.9 |  |  |
| Intel | MIL (dB) | 165.7 | 166.9 | 163.5 | 166.4 | 164.1 | 165.7 | 162.0 | 160.8 | 158.2 | 143.9 | 154.6 | 156.8 | 143.9 |
| Margin (dB) | 21.7 | 23.0 | 19.6 | 22.4 | 20.1 | 21.8 | 18.1 | 16.8 | 14.2 | 0.0 | 10.6 | 12.8 |  |

**Table 3.1-2: Link budget performance for the RedCap UE (20MHz BW, 2Rx)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Urban 2.6GHz, 2Rx RedCap UE** | | | | | | | | | | | | | | |
|  |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22bits | PUSCH | Msg3 | PRACH | Target /Option3 |
| Samsung | MIL (dB) | 160.1 | 164.1 | 156.7 | 155.8 | 156.7 |  | 155.2 | 151.6 | 148.3 | 136.4 | 147.0 |  | 139.4 |
| Margin (dB) | 20.6 | 24.6 | 17.2 | 16.3 | 17.2 |  | 15.8 | 12.2 | 8.9 | -3.0 | 7.6 |  |  |
| ZTE | MIL (dB) |  |  |  |  |  |  | 159.6 | 157.9 | 155.4 | 139.0 | 153.5 |  | 142.0 |
| Margin (dB) |  |  |  |  |  |  | 17.7 | 15.9 | 13.4 | -3.0 | 11.5 |  |  |
| OPPO | MIL (dB) | 161.2 | 165.2 | 164.6 | 155.2 | 159.0 |  | 151.9 | 152.0 | 151.9 | 141.9 | 151.7 |  | 145.1 |
| Margin (dB) | 16.0 | 20.0 | 19.5 | 10.1 | 13.8 |  | 6.8 | 6.8 | 6.7 | -3.2 | 6.6 |  |  |
| CATT | MIL (dB) | 159.2 | 163.2 | 161.7 | 153.7 | 157.4 |  | 157.3 | 155.9 | 153.9 | 142.9 | 150.5 |  | 145.9 |
| Margin (dB) | 13.2 | 17.2 | 15.7 | 7.8 | 11.4 |  | 11.4 | 10.0 | 7.9 | -3.0 | 4.6 |  |  |
| vivo | MIL (dB) | 151.9 | 160.0 | 154.9 | 149.6 | 151.4 | 155.4 | 153.2 | 150.6 | 148.1 | 135.0 | 149.4 | 146.7 | 137.8 |
| Margin (dB) | 14.2 | 22.2 | 17.2 | 11.8 | 13.7 | 17.6 | 15.4 | 12.9 | 10.3 | -2.8 | 11.6 | 8.9 |  |
| Xiaomi | MIL (dB) | 160.8 | 160.8 | 160.9 | 155.4 | 158.4 |  | 158.6 | 155.9 | 154.2 | 143.7 | 151.6 |  | 146.7 |
| Margin (dB) | 14.0 | 14.0 | 14.1 | 8.6 | 11.6 |  | 11.9 | 9.2 | 7.5 | -3.0 | 4.9 |  |  |
| Futurewei | MIL (dB) | 159.0 | 161.0 | 159.3 | 157.3 | 158.1 |  |  |  |  | 148.6 | 150.5 |  | 151.6 |
| Margin (dB) | 7.3 | 9.3 | 7.6 | 5.6 | 6.4 |  |  |  |  | -3.0 | -1.1 |  |  |
| Nokia | MIL (dB) | 162.5 | 162.5 | 160.3 | 161.5 | 160.3 |  | 148.7 |  | 147.2 | 135.6 | 144.8 | 147.3 | 138.6 |
| Margin (dB) | 23.9 | 23.9 | 21.7 | 22.9 | 21.7 |  | 10.1 |  | 8.6 | -3.0 | 6.2 | 8.7 |  |
| DOCOMO | MIL (dB) | 159.8 | 163.8 | 159.9 | 152.9 | 156.0 |  | 158.1 | 161.9 |  | 142.7 | 151.6 |  | 145.7 |
| Margin (dB) | 14.1 | 18.1 | 14.1 | 7.2 | 10.3 |  | 12.4 | 16.2 |  | -3.0 | 5.9 |  |  |
| CMCC | MIL (dB) | 157.2 | 162.8 | 161.1 | 154.6 | 157.4 | 158.8 | 153.3 | 151.5 | 149.3 | 136.8 | 149.8 | 155.6 | 139.8 |
| Margin (dB) | 17.4 | 23.0 | 21.3 | 14.8 | 17.6 | 19.0 | 13.5 | 11.7 | 9.6 | -3.0 | 10.1 | 15.9 |  |
| Panasonic | MIL (dB) |  | 163.5 | 154.7 |  |  |  |  |  |  |  |  |  |  |
| Margin (dB) |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Huawei | MIL (dB) | 158.0 | 162.0 | 156.9 | 154.6 | 154.6 |  | 157.6 |  | 155.3 | 136.0 | 146.6 |  | 139.0 |
| Margin (dB) | 19.0 | 23.0 | 17.9 | 15.7 | 15.6 |  | 18.6 |  | 16.3 | -3.0 | 7.7 |  |  |
| Spreadtrum | MIL (dB) | 159.0 | 163.0 | 160.9 | 157.8 | 157.8 | 160.3 | 155.4 | 153.6 | 153.2 | 142.7 | 147.5 | 152.8 | 145.7 |
| Margin (dB) | 13.2 | 17.2 | 15.1 | 12.0 | 12.0 | 14.5 | 9.7 | 7.9 | 7.5 | -3.0 | 1.8 | 7.0 |  |
| Apple | MIL (dB) | 154.4 | 162.4 | 157.4 | 147.3 | 150.4 |  |  |  | 147.8 | 137.0 | 141.7 |  | 140.0 |
| Margin (dB) | 14.4 | 22.4 | 17.4 | 7.3 | 10.4 |  |  |  | 7.8 | -3.0 | 1.8 |  |  |
| Ericsson | MIL (dB) | 155.8 | 155.8 | 156.5 | 150.2 | 152.9 | 157.8 | 151.9 | 152.5 | 150.6 | 140.9 | 148.2 | 152.1 | 143.9 |
| Margin (dB) | 11.8 | 11.8 | 12.5 | 6.2 | 8.9 | 13.8 | 8.0 | 8.6 | 6.7 | -3.0 | 4.3 | 8.1 |  |
| InterDigital | MIL (dB) | 158.77 | 162.8 | 160.29 | 153.87 | 156.80 |  | 157.1 |  | 152.8 | 140.24 | 149.84 |  | 143.24 |
| Margin (dB) | 15.53 | 19.56 | 17.05 | 10.63 | 13.56 |  | 13.86 |  | 9.56 | -3.0 | 6.6 |  |  |
| Qualcomm | MIL (dB) | 155.8 |  | 157.8 | 152.0 | 154.3 |  |  |  | 143.5 | 136.4 | 145.2 |  | 139.4 |
| Margin (dB) | 16.5 |  | 18.4 | 12.6 | 14.9 |  |  |  | 4.2 | -3.0 | 5.9 |  |  |
| Intel | MIL (dB) | 159.8 | 161.0 | 157.6 | 160.7 | 158.0 | 162.7 | 159.0 | 157.8 | 155.2 | 140.9 | 151.6 | 153.8 | 143.9 |
| Margin (dB) | 15.8 | 17.1 | 13.7 | 16.7 | 14.0 | 18.8 | 15.1 | 13.8 | 11.2 | -3.0 | 7.6 | 9.8 |  |

**Table 3.1-3: Link budget performance for the RedCap UE (20MHz BW, 1Rx)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Urban 2.6GHz, 1Rx RedCap UE** | | | | | | | | | | | | | | |
|  |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22bits | PUSCH | Msg3 | PRACH | Target /Option3 |
| Samsung | MIL (dB) | 156.6 | 160.6 | 151.9 | 150.6 | 153.2 |  | 155.2 | 151.6 | 148.3 | 136.4 | 147.0 |  | 139.4 |
| Margin (dB) | 17.1 | 21.1 | 12.4 | 11.1 | 13.7 |  | 15.8 | 12.2 | 8.9 | -3.0 | 7.6 |  |  |
| ZTE | MIL (dB) | 147.8 | 158.3 | 160.8 | 151.0 | 151.4 |  | 159.6 | 157.9 | 155.4 | 139.0 | 153.5 |  | 142.0 |
| Margin (dB) | 5.9 | 16.3 | 18.8 | 9.0 | 9.4 |  | 17.7 | 15.9 | 13.4 | -3.0 | 11.5 |  |  |
| OPPO | MIL (dB) | 157.2 | 161.2 | 162.0 | 149.2 | 155.1 |  | 151.9 | 152.0 | 151.9 | 141.9 | 151.7 |  | 145.1 |
| Margin (dB) | 12.1 | 16.1 | 16.9 | 4.1 | 9.9 |  | 6.8 | 6.8 | 6.7 | -3.2 | 6.6 |  |  |
| CATT | MIL (dB) | 155.5 | 159.5 | 157.8 | 147.6 | 154.0 |  | 157.3 | 155.9 | 153.9 | 142.9 | 150.5 |  | 145.9 |
| Margin (dB) | 9.5 | 13.5 | 11.9 | 1.6 | 8.0 |  | 11.4 | 10.0 | 7.9 | -3.0 | 4.6 |  |  |
| vivo | MIL (dB) | 148.7 | 156.8 | 150.6 | 144.7 | 146.8 | 152.3 | 153.2 | 150.6 | 148.1 | 135.0 | 149.4 | 146.7 | 137.8 |
| Margin (dB) | 10.9 | 19.0 | 12.8 | 6.9 | 9.0 | 14.5 | 15.4 | 12.9 | 10.3 | -2.8 | 11.6 | 8.9 |  |
| Xiaomi | MIL (dB) | 157.6 | 157.6 | 157.3 | 150.2 | 154.4 |  | 158.6 | 155.9 | 154.2 | 143.7 | 151.6 |  | 146.7 |
| Margin (dB) | 10.9 | 10.9 | 10.5 | 3.4 | 7.6 |  | 11.9 | 9.2 | 7.5 | -3.0 | 4.9 |  |  |
| Futurewei | MIL (dB) | 156.4 | 158.4 | 157.3 | 154.3 | 154.9 |  |  |  |  | 148.6 | 150.5 |  | 151.6 |
| Margin (dB) | 4.7 | 6.7 | 5.6 | 2.6 | 3.2 |  |  |  |  | -3.0 | -1.1 |  |  |
| Nokia | MIL (dB) | 158.5 | 158.5 | 156.8 | 157.8 | 156.5 |  | 148.7 |  | 147.2 | 135.6 | 144.8 | 147.3 | 138.6 |
| Margin (dB) | 19.9 | 19.9 | 18.2 | 19.2 | 17.9 |  | 10.1 |  | 8.6 | -3.0 | 6.2 | 8.7 |  |
| DOCOMO | MIL (dB) | 156.4 | 160.4 | 155.7 | 147.3 | 151.9 |  | 158.1 | 161.9 |  | 142.7 | 151.6 |  | 145.7 |
| Margin (dB) | 10.7 | 14.7 | 10.0 | 1.5 | 6.1 |  | 12.4 | 16.2 |  | -3.0 | 5.9 |  |  |
| CMCC | MIL (dB) |  |  |  |  |  |  | 153.3 | 151.5 | 149.3 | 136.8 | 149.8 | 155.6 | 139.8 |
| Margin (dB) |  |  |  |  |  |  | 13.5 | 11.7 | 9.6 | -3.0 | 10.1 | 15.9 |  |
| Panasonic | MIL (dB) |  | 160.6 | 150.9 |  |  |  |  |  |  |  |  |  |  |
| Margin (dB) |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Huawei | MIL (dB) | 154.9 | 158.9 | 153.1 | 150.3 | 150.7 |  | 157.6 |  | 155.3 | 136.0 | 146.6 |  | 139.0 |
| Margin (dB) | 15.9 | 19.9 | 14.1 | 11.4 | 11.7 |  | 18.6 |  | 16.3 | -3.0 | 7.7 |  |  |
| Spreadtrum | MIL (dB) | 156.0 | 160.0 | 157.9 | 154.8 | 154.8 | 157.3 | 155.4 | 153.6 | 153.2 | 142.7 | 147.5 | 152.8 | 145.7 |
| Margin (dB) | 10.2 | 14.2 | 12.1 | 9.0 | 9.0 | 11.5 | 9.7 | 7.9 | 7.5 | -3.0 | 1.8 | 7.0 |  |
| Apple | MIL (dB) | 151.0 | 159.0 | 152.8 | 141.8 | 146.1 |  |  |  | 147.8 | 137.0 | 141.7 |  | 140.0 |
| Margin (dB) | 11.0 | 19.0 | 12.8 | 1.8 | 6.1 |  |  |  | 7.8 | -3.0 | 1.8 |  |  |
| Ericsson | MIL (dB) | 152.8 | 152.8 | 153.3 | 145.3 | 148.9 | 153.9 | 151.9 | 152.5 | 150.6 | 140.9 | 148.2 | 152.1 | 143.9 |
| Margin (dB) | 8.8 | 8.8 | 9.3 | 1.3 | 4.9 | 9.9 | 8.0 | 8.6 | 6.7 | -3.0 | 4.3 | 8.1 |  |
| InterDigital | MIL (dB) | 155.57 | 159.57 | 157.22 | 149.27 | 153.69 |  | 157.1 |  | 152.8 | 140.24 | 149.84 |  | 143.24 |
| Margin (dB) | 12.33 | 16.33 | 13.98 | 6.03 | 10.45 |  | 13.86 |  | 9.56 | -3.0 | 6.6 |  |  |
| Qualcomm | MIL (dB) | 152.5 |  | 154.7 | 148.1 | 151.0 |  |  |  | 143.5 | 136.4 | 145.2 |  | 139.4 |
| Margin (dB) | 13.2 |  | 15.3 | 8.7 | 11.6 |  |  |  | 4.2 | -3.0 | 5.9 |  |  |
| Intel | MIL (dB) |  |  |  |  |  |  | 159.0 | 157.8 | 155.2 | 140.9 | 151.6 | 153.8 | 143.9 |
| Margin (dB) |  |  |  |  |  |  | 15.1 | 13.8 | 11.2 | -3.0 | 7.6 | 9.8 |  |

**Question 3.1-1: Can the link budget evaluation results in Table 3.1-1 to Table 3.1-3 be captured to TR 38.875? (Companies are invited to check the result and if any modification is needed, please also indicate here.)**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo |  | If possible, it would be useful to clarify the assumption in the simulation   1. For PRACH, the simulated format 2. For MSG2, whether existing TBS scaling is used? |
| ZTE | Y | Fine to capture the tables into the TR. |
| Qualcomm | Y | We think the results for Urban 2.6GHz are relatively stable. |
| Nokia, NSB | Y |  |
| Futurewei |  | We think having a summary observation as in question 3.1-2 is more important than including all link budget evaluation results in the TR, so if agree to this it should be in addition to the summary observation.  A conclusion could be in the form of mentioning the assumption of the option (Option 1 or 3), choice of MIL/ MPL/ MCL and the resulting channel that may need compensation. Something like table 3.1-4. Representative values are preferred. Also assumptions on Msg2 could vary widely due to having different number of user.  If included, we recommend to note it will be in an Appendix and using 'Source 1' etc rather than company names like 36.888. (keeping the company names is good for now for checking) |
| NTT DOCOMO | Y |  |
| Ericsson | Y |  |
| CATT | Y |  |
| Intel | Y | Fine to capture the tables into TR |
| Samsung |  | For Msg 2, it should be clarified whether or not Rel-15 TBS scaling was applied for each simulation result. |
| InterDigital | Y | We have provide some update on our results. |
| FL4 | Majority of responses are fine with capturing the above link budget evaluation results to TR 38.875. One response suggests the results can be captured in an Appendix of TR 38.875 by replacing company names with “source N”. Several responses comment to clarify evaluation assumption for msg2 and PRACH.  For Msg2 results, some companies might have considered TBS scaling and some others have not. However, the assumption for TBS scaling is not available in the evaluation spreadsheet. FL suggests the sourcing companies to clarify whether TBS scaling is used for Msg2 and also PRACH format.  Based on the responses, FL makes the following proposal:  **[FL4] Proposal 3.1-1:**   * Capture the link budget evaluation results (Urban 2.6 GHz) in Table 3.1-1 to Table 3.1-3 to the Appendix of TR 38.875   + The tables will be further updated with potential updated coverage recovery evaluation results and a clarification of assumption for Msg2 and PRACH. | |
| vivo |  | For MSG2, we use MCS#0 with no TBS scaling  For PRACH, only format B4 is captured according to the template. However, we believe for TDD, PRACH format 0 is possible for better coverage, therefore not proper to draw conclusion based on PRACH format B4 only. We also provided results for format 0 in the contribution R1-2007670 |
| Qualcomm |  | We are fine with the FL updated proposal  For Msg2, no TBS scaling is used (3 RBs, MCS0, and TBS = 9 bytes) |
| Huawei, Hisilicon | N | Since the margin value assumes only “Option 3” which has not been agreed yet. We prefer to wait until proposal 1 is agreed.  In addition MIL, MPL results should also be captured in TR. We suggest FL to treat them equally. |
| Futurewei |  | No tbs scaling |
| Intel | Y | We simulate Msg2 with scaling factor 1/4 and PRACH format B4 |
| Ericsson |  | We are fine with the FL’s updated proposal.  Regarding TBS scaling for Msg2, we have provided results with and without TBS scaling. We suggest using results based on no TBS scaling as a baseline. TBS scaling can be considered as a coverage recovery technique for Msg2.  Regarding PRACH, our results are based on Format B4 (30 KHz SCS). |
| Samsung |  | No TBS scaling was used for Msg2. |
| CATT |  | For Msg2, we use MCS#0 with no TBS scaling. |
| Xiaomi |  | For Msg.2, we use MCS#0 w/o TBS scaling |
| ZTE |  | We are fine with the proposal.  For Msg.2, we use (3 RBs, MCS#0, TBS = 9 bytes) w/o TBS scaling. |
| CMCC |  | For Msg2, we use MCS#0 with no TBS scaling.  For PRACH, we use Format B4. |
| InterDigital |  | For Msg2, we used 3 RBs, MCS0, 72 bits. |
| OPPO |  | For Msg2, we used 3 RBs, MCS0, without TBS scaling. |
| **FL5** | Based on the received responses, the FL’s updated suggestion is as following.  **[FL5] Updated Proposal 3.1-1:**   * Capture the link budget evaluation results (Urban 2.6 GHz) in Table 3.1-1 to Table 3.1-3 to the Appendix of TR 38.875   + The tables will be further updated with potential updated evaluation results (to catch potential typos) and a clarification of assumption for Msg2 and PRACH.   + MPL results to be included also. Up to editor to use the same or different tables. | |
| Panasonic | Y |  |
| vivo |  | Fine with the proposal. |

Based on the evaluation results in Table 3.1-1, 3.1-2 and 3.1-3, the channels that potentially need coverage recovery in Urban scenario at 2.6 GHz and the summary of companies evaluation results for the margin to the coverage recovery target (i.e. the MIL of bottleneck channel for the reference NR UE) are summarized in Table 3.1-4, where the numbers in bracket is the number of samples.

**Table 3.1-4: Coverage recovery for RedCap UE in Urban scenario at 2.6 GHz (Option 3)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Channels | Mean | Median | Range | Representative value |
| 2Rx RedCap | PUSCH (17) | **-3.0** | **-3.0** | **0.4** | **-3.0** |
| 1Rx RedCap | PUSCH (17) | **-3.0** | **-3.0** | **0.4** | **-3.0** |

**Question 3.1-2: Can Table 3.1-4 be captured to TR 38.875? If not, any other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| FL |  | Table 3.1-4 has been updated by considering all the companies’ evaluation results. The representative value in the table is expected to be updated based on the agreement for the coverage recovery target in section 2, and the positive representative value indicates the LB of the concerned channel is better than the MIL of the bottleneck channel of the reference NR UE. |
| ZTE |  | Considering there is an FFS point regarding how to use the representative value as discussed in section 2, it may be also necessary to capture the representative value for case ‘100MHz BW, 4Rx’. In addition, it would be more informative if we can provide the representative values for all channels, e.g., by adding a row for representative value for each channel in Table 3.1.1~3.1.4. Of course, it would need tremendous efforts from moderator.  *Details are FFS (e.g. coverage recovery is not needed if the representative value of a channel is larger than zero)* |
| Qualcomm | N | Prefer to wait until proposal 1 is stable/agreed |
| Nokia, NSB |  | We prefer to wait until proposal 1 is agreed. The details of how the amount for coverage recovery will be determined from the representative value is FFS. If the representative value is meant to indicate the amount of coverage recovery, then we think that it is better to resolve the FFS first before agreeing to capture this table. |
| Futurewei | Y | 2.6 GHz seems to be consistent as such conclusion is OK |
| NTT DOCOMO |  | The outcome is derived based on the current proposal in Section 2, it may be better to wait the consensus in Section2, though we are fine with the proposal. |
| Ericsson | Y | It appears that the results from all companies are well aligned.  We suggest clarifying (1) the meaning of the numbers in parentheses, and (2) how the range is computed (e.g., maximum-minimum) |
| CATT | Y | Generally fine.  Also, we think the values in the above table are more like ‘coverage loss’ compared to the bottleneck channel, a little different from ‘coverage recovery’ which are still under discussion in proposal 1. May consider revising the title from ‘recovery’ to ‘loss’. |
| Intel |  | The table can be formed after proposal is section 2 is finalized. |
| Samsung |  | FFS in proposal #1 should be determined before agreeing this. |
| Huawei, Hisilicon | N | We prefer to wait until proposal 1 is agreed. The representative value is apparently related to the target performance requirements. |
| Xiaomi |  | It would be better to wait for more stable proposal 1 |
| OPPO |  | Share the comments with Samsung. |

Based on the results in Table 3.1-4, the following observations are proposed for discussion for the TP drafting for TR 38.875.

**Moderator’s observation**

* P1: For RedCap UE in Urban scenario at 2.6 GHz, PUSCH is the channel that needs recovery and the amount of compensation is approximately 3Db.
* P2: A coverage degradation of approximately 1 dB relative to the target coverage is observed for Msg3 at 2.6 GHz carrier frequency by one source company
* P3: For a RedCap UE with 1Rx and 2 Rx antenna at 2.6 GHz carrier frequency, all downlink channels can reach the target coverage requirement thus requiring no compensation

**Question 3.1-3: Can the above list (P1-P3) be used as a baseline text for TR 38.875? If not, what other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | N | Prefer to wait until proposal 1 is stable/agreed |
| Nokia, NSB |  | We prefer to wait until proposal 1 is agreed |
| Futurewei | Y | Can add that MIL was used for this analysis |
| NTT DOCOMO |  | We can wait the agreement of proposal 1. |
| Ericsson |  | P1: For PUSCH, it can be clarified the 3 dB coverage compensation is needed if the target data rate for RedCap Ues is the same as reference UE. We should add a note here to state that the 3 dB coverage compensation is not needed if the target data rate for RedCap Ues is reduced.  We can further mention that the 3 dB loss is resulting from the UE antenna efficiency loss assumed for the wearable use cases only. |
| CATT |  | Generally fine with the observation. Also OK to wait until further progress of proposal 1 is made. |
| Samsung |  | It can be mentioned that 3dB antenna loss is resulted from reduced antenna efficiency due to device size limitations for wearables. |
| Huawei, Hisilicon | N | We prefer to wait until proposal 1 is agreed. |
| Xiaomi |  | It would be better to wait for more stable proposal 1 |

**[FL5] Based on the received responses, the FL’s updated text proposal is as following.**

**(FL note: based on the outcome of Proposal 2-1, some numbers in the tables can be further updated, however, the conclusion is expected to be same)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| For Urban scenario at 2.6 GHz, the bottleneck channel for the reference NR UE and the corresponding maximum isotropic loss (MIL) value by the sourcing companies are shown in Table 9.1-1. The estimated coverage loss for the RedCap UE relative to the bottleneck channel of the reference NR UE is summarized in Table 9.1-2 and Table 9.1-3. It is noted that the 3dB antenna efficiency loss is assumed in both DL and UL for the RedCap UE.  **Table 9.1-1: Bottleneck channel and MIL value for Reference NR UE in Urban 2.6 GHz**   |  |  |  | | --- | --- | --- | |  | Bottleneck Channel | MIL (dB) | | Samsung | PUSCH | 139.4 | | ZTE | PUSCH | 142.0 | | OPPO | PUSCH | 145.1 | | CATT | PUSCH | 145.9 | | vivo | PUSCH | 137.8 | | Xiaomi | PUSCH | 146.7 | | Futurewei | PUSCH | 151.6 | | Nokia | PUSCH | 138.6 | | DCM | PUSCH | 145.7 | | CMCC | PUSCH | 139.8 | | Huawei | PUSCH | 139.0 | | SPRD | PUSCH | 145.7 | | Apple | PUSCH | 140.0 | | Ericsson | PUSCH | 143.9 | | IDCC | PUSCH | 143.2 | | QC | PUSCH | 139.4 | | Intel | PUSCH | 143.9 |   The representative values in the last row of Table 9.1-2 and Table 9.1-3 are derived by taking the mean value (in dB domain) from all the companies results and excluding the highest and the lowest values when the number of samples is more than 3. A negative value of the representative value for a channel of the RedCap UE indicates the coverage of the channel is worse than that of the bottleneck channel of the reference NR UE and coverage recovery is needed.  As can be seen in the last row for the representative value, all the channels except for PUSCH have better coverage than that of the bottleneck channel thus requiring no compensation. On average, a coverage degradation of approximately 3dB is observed for PUSCH.  It should be noted that the 3dB loss is resulted from the UE antenna efficiency loss assumed for the wearable use cases. Furthermore, the same target data rate of 1Mbps for PUSCH is assumed for both RedCap UE and the reference UE (see evaluation methodology described in clause 6.3). A smaller coverage loss for PUSCH is expected if the target data rate for RedCap UE is reduced.  **Table 9.1-2: Coverage loss (dB) for 2Rx RedCap UE in Urban scenario at 2.6 GHz (Option 3)**   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22 bits | PUSCH | Msg3 | PRACH | | Samsung | 20.6 | 24.6 | 17.2 | 16.3 | 17.2 |  | 15.8 | 12.2 | 8.9 | -3.0 | 7.6 |  | | ZTE |  |  |  |  |  |  | 17.7 | 15.9 | 13.4 | -3.0 | 11.5 |  | | OPPO | 16.0 | 20.0 | 19.5 | 10.1 | 13.8 |  | 6.8 | 6.8 | 6.7 | -3.2 | 6.6 |  | | CATT | 13.2 | 17.2 | 15.7 | 7.8 | 11.4 |  | 11.4 | 10.0 | 7.9 | -3.0 | 4.6 |  | | vivo | 14.2 | 22.2 | 17.2 | 11.8 | 13.7 | 17.6 | 15.4 | 12.9 | 10.3 | -2.8 | 11.6 | 8.9 | | Xiaomi | 14.0 | 14.0 | 14.1 | 8.6 | 11.6 |  | 11.9 | 9.2 | 7.5 | -3.0 | 4.9 |  | | Futurewei | 7.3 | 9.3 | 7.6 | 5.6 | 6.4 |  |  |  |  | -3.0 | -1.1 |  | | Nokia | 23.9 | 23.9 | 21.7 | 22.9 | 21.7 |  | 10.1 |  | 8.6 | -3.0 | 6.2 | 8.7 | | DCM | 14.1 | 18.1 | 14.1 | 7.2 | 10.3 |  | 12.4 | 16.2 |  | -3.0 | 5.9 |  | | CMCC | 17.4 | 23.0 | 21.3 | 14.8 | 17.6 | 19.0 | 13.5 | 11.7 | 9.6 | -3.0 | 10.1 | 15.9 | | Huawei | 19.0 | 23.0 | 17.9 | 15.7 | 15.6 |  | 18.6 |  | 16.3 | -3.0 | 7.7 |  | | SPRD | 13.2 | 17.2 | 15.1 | 12.0 | 12.0 | 14.5 | 9.7 | 7.9 | 7.5 | -3.0 | 1.8 | 7.0 | | Apple | 14.4 | 22.4 | 17.4 | 7.3 | 10.4 |  |  |  | 7.8 | -3.0 | 1.8 |  | | Ericsson | 11.8 | 11.8 | 12.5 | 6.2 | 8.9 | 13.8 | 8.0 | 8.6 | 6.7 | -3.0 | 4.3 | 8.1 | | IDCC | 15.5 | 19.6 | 17.1 | 10.6 | 13.6 |  | 13.9 |  | 9.6 | -3.0 | 6.6 |  | | QC | 16.5 |  | 18.4 | 12.6 | 14.9 |  |  |  | 4.2 | -3.0 | 5.9 |  | | Intel\* | 15.8 | 17.1 | 13.7 | 16.7 | 14.0 | 18.8 | 15.1 | 13.8 | 11.2 | -3.0 | 7.6 | 9.8 | | Representative value (dB) | **15.4** | **19.2** | **16.5** | **11.3** | **13.2** | **17.0** | **12.9** | **11.3** | **8.9** | **-3.0** | **6.2** | **8.9** |   Note: A TBS scaling factor ¼ is assumed for Msg2 evaluation  **Table 9.1-3: Coverage loss (dB) for 1Rx RedCap UE in Urban scenario at 2.6 GHz (Option 3)**   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22 bits | PUSCH | Msg3 | PRACH | | Samsung | 17.1 | 21.1 | 12.4 | 11.1 | 13.7 |  | 15.8 | 12.2 | 8.9 | -3.0 | 7.6 |  | | ZTE | 5.9 | 16.3 | 18.8 | 9.0 | 9.4 |  | 17.7 | 15.9 | 13.4 | -3.0 | 11.5 |  | | OPPO | 12.1 | 16.1 | 16.9 | 4.1 | 9.9 |  | 6.8 | 6.8 | 6.7 | -3.2 | 6.6 |  | | CATT | 9.5 | 13.5 | 11.9 | 1.6 | 8.0 |  | 11.4 | 10.0 | 7.9 | -3.0 | 4.6 |  | | vivo | 10.9 | 19.0 | 12.8 | 6.9 | 9.0 | 14.5 | 15.4 | 12.9 | 10.3 | -2.8 | 11.6 | 8.9 | | Xiaomi | 10.9 | 10.9 | 10.5 | 3.4 | 7.6 |  | 11.9 | 9.2 | 7.5 | -3.0 | 4.9 |  | | Futurewei | 4.7 | 6.7 | 5.6 | 2.6 | 3.2 |  |  |  |  | -3.0 | -1.1 |  | | Nokia | 19.9 | 19.9 | 18.2 | 19.2 | 17.9 |  | 10.1 |  | 8.6 | -3.0 | 6.2 | 8.7 | | DCM | 10.7 | 14.7 | 10.0 | 1.5 | 6.1 |  | 12.4 | 16.2 |  | -3.0 | 5.9 |  | | CMCC |  |  |  |  |  |  | 13.5 | 11.7 | 9.6 | -3.0 | 10.1 | 15.9 | | Huawei | 15.9 | 19.9 | 14.1 | 11.4 | 11.7 |  | 18.6 |  | 16.3 | -3.0 | 7.7 |  | | SPRD | 10.2 | 14.2 | 12.1 | 9.0 | 9.0 | 11.5 | 9.7 | 7.9 | 7.5 | -3.0 | 1.8 | 7.0 | | Apple | 11.0 | 19.0 | 12.8 | 1.8 | 6.1 |  |  |  | 7.8 | -3.0 | 1.8 |  | | Ericsson | 8.8 | 8.8 | 9.3 | 1.3 | 4.9 | 9.9 | 8.0 | 8.6 | 6.7 | -3.0 | 4.3 | 8.1 | | IDCC | 12.3 | 16.3 | 14.0 | 6.0 | 10.5 |  | 13.9 |  | 9.6 | -3.0 | 6.6 |  | | QC | 13.2 |  | 15.3 | 8.7 | 11.6 |  |  |  | 4.2 | -3.0 | 5.9 |  | | Intel\* |  |  |  |  |  |  | 15.1 | 13.8 | 11.2 | -3.0 | 7.6 | 9.8 | | Representative value (dB) | **11.4** | **15.7** | **13.1** | **5.9** | **9.1** | **12.0** | **12.9** | **11.3** | **8.9** | **-3.0** | **6.2** | **8.9** |   Note: A TBS scaling factor ¼ is assumed for Msg2 evaluation |

**[FL5] Question 3.1-1A:** **Can the above observations of the relative coverage loss be used as a baseline text for TR 38.875? If not, what aspects to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Panasonic | Y |  |
| vivo |  | It would be useful to make if clear   * + - 1. All companies except one company does not apply TBS scaling for MSG2       2. PRACH format B4 is simulated |
|  |  |  |

## FR1, Rural with the carrier frequency of 0.7 GHz

Based on the latest available evaluation results in [RedCapCoverage-700MHz-v018-Panasonic](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/drafts/8.6/EvaluationResults/RedCapCoverage/700MHz/RedCapCoverage-700MHz-v018-Panasonic.xlsx), the link budget performance for both the reference UE and RedCap UE in rural scenario at 0.7GHz is summarized in Table 3.2-1 to Table 3.2-3 (Company please double check whether your results are correctly captured in these tables. We have found there are some mismatch between the spreadsheet and the contribution for some companies results).

In the link budget tables, the maximum isotropic loss (MIL) is used as the coverage evaluation metric and for each channel the margin to the target performance is also shown, where the target performance is a company specific value and derived based on the link budget of the bottleneck channel for the reference NR UE (i.e. Option 3). The coverage limiting channel for RedCap UE, e.g. the link budget for the channel worse than that target performance, is highlighted with RED.

**Table 3.2-1: Link budget performance for the reference NR UE (20MHz BW, 2Rx)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Rural 700MHz, 2Rx Reference UE** | | | | | | | | | | | | | | |
|  |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22bits | PUSCH | Msg3 | PRACH | Target /Option3 |
| Samsung | MIL (dB) | 162.4 | 162.4 | 157.9 | 157.9 | 158.9 |  | 158.3 | 154.5 | 151.5 | 146.6 | 149.5 |  | 146.6 |
| Margin (dB) | 15.9 | 15.9 | 11.4 | 11.4 | 12.4 |  | 11.7 | 7.9 | 4.9 | 0.0 | 2.9 |  |  |
| ZTE | MIL (dB) | 154.8 | 158.5 | 157.4 | 154.4 | 154.7 |  | 152.6 | 150.6 | 147.9 | 143.6 | 143.2 |  | 143.2 |
| Margin (dB) | 11.6 | 15.3 | 14.2 | 11.2 | 11.5 |  | 9.4 | 7.4 | 4.7 | 0.4 | 0.0 |  |  |
| OPPO | MIL (dB) | 163.1 | 163.1 | 162.0 | 157.0 | 161.0 |  | 149.0 | 149.1 | 148.9 | 150.0 | 149.5 |  | 148.9 |
| Margin (dB) | 14.2 | 14.2 | 13.0 | 8.0 | 12.1 |  | 0.1 | 0.2 | 0.0 | 1.1 | 0.5 |  |  |
| CATT | MIL (dB) | 158.7 | 158.7 | 155.9 | 153.5 | 156.8 |  | 156.7 | 155.4 | 153.3 | 147.9 | 150.7 |  | 147.9 |
| Margin (dB) | 10.7 | 10.7 | 8.0 | 5.6 | 8.9 |  | 8.7 | 7.5 | 5.4 | 0.0 | 2.7 |  |  |
| vivo | MIL (dB) | 155.0 | 155.1 | 152.0 | 149.8 | 152.7 | 159.2 | 150.3 | 147.4 | 145.0 | 144.0 | 146.3 | 145.7 | 144.0 |
| Margin (dB) | 11.0 | 11.1 | 8.0 | 5.8 | 8.8 | 15.2 | 6.3 | 3.5 | 1.1 | 0.0 | 2.3 | 1.7 |  |
| Xiaomi | MIL (dB) | 160.0 | 160.0 | 157.6 | 154.9 | 158.1 |  | 158.0 | 155.4 | 152.9 | 149.7 | 150.9 |  | 149.7 |
| Margin (dB) | 10.3 | 10.3 | 7.9 | 5.2 | 8.4 |  | 8.3 | 5.7 | 3.2 | 0.0 | 1.2 |  |  |
| Futurewei | MIL (dB) | 161.1 | 161.1 | 158.1 | 157.9 | 159.1 |  |  |  |  | 150.8 | 153.0 |  | 150.8 |
| Margin (dB) | 10.4 | 10.4 | 7.4 | 7.2 | 8.4 |  |  |  |  | 0.0 | 2.2 |  |  |
| Nokia | MIL (dB) | 158.0 | 158.0 | 159.5 | 156.7 | 159.4 |  | 144.9 |  | 143.7 | 144.2 | 138.5 | 147.9 | 138.5 |
| Margin (dB) | 19.5 | 19.5 | 21.0 | 18.1 | 20.9 |  | 6.4 |  | 5.2 | 5.6 | 0.0 | 9.4 |  |
| DOCOMO | MIL (dB) | 162.5 | 162.5 | 158.1 | 155.1 | 158.1 |  | 155.9 | 161.2 |  | 146.7 | 149.5 |  | 146.7 |
| Margin (dB) | 15.8 | 15.8 | 11.4 | 8.4 | 11.4 |  | 9.2 | 14.6 |  | 0.0 | 2.8 |  |  |
| Panasonic | MIL (dB) |  | 161.8 | 151.8 |  |  |  | 152.6 | 150.2 | 146.2 | 141.8 | 144.6 |  | 141.8 |
| Margin (dB) |  | 20.0 | 10.0 |  |  |  | 10.8 | 8.4 | 4.4 | 0.0 | 2.8 |  |  |
| Huawei | MIL (dB) | 157.2 | 157.2 | 152.9 | 152.9 | 153.6 |  | 152.8 |  | 150.6 | 141.8 | 145.3 |  | 141.8 |
| Margin (dB) | 15.5 | 15.5 | 11.1 | 11.1 | 11.8 |  | 11.0 |  | 8.8 | 0.0 | 3.5 |  |  |
| Spreadtrum | MIL (dB) | 161.0 | 161.0 | 159.0 | 160.0 | 160.0 | 163.0 | 160.5 | 157.5 | 157.3 | 151.5 | 154.5 | 156.8 | 151.5 |
| Margin (dB) | 9.6 | 9.6 | 7.6 | 8.6 | 8.6 | 11.6 | 9.0 | 6.0 | 5.8 | 0.0 | 3.0 | 5.4 |  |
| Apple | MIL (dB) | 157.7 | 157.7 | 155.9 | 151.5 | 155.7 |  |  |  |  | 143.7 |  |  | 143.7 |
| Margin (dB) | 14.0 | 14.0 | 12.2 | 7.8 | 12.0 |  |  |  |  | 0.0 |  |  |  |
| Ericsson | MIL (dB) | 157.3 | 156.6 | 155.6 | 153.2 | 155.9 | 157.3 | 149.4 | 157.9 | 147.4 | 142.9 | 145.0 | 147.9 | 142.9 |
| Margin (dB) | 14.5 | 13.8 | 12.8 | 10.4 | 13.1 | 14.5 | 6.5 | 15.0 | 4.5 | 0.0 | 2.1 | 5.1 |  |
| InterDigital | MIL (dB) | 161.2 | 161.2 | 158.5 | 152.31 | 155.16 |  | 155.8 |  | 150.8 | 146.7 | 144.44 |  | 144.44 |
| Margin (dB) | 16.76 | 16.76 | 14.06 | 7.87 | 10.72 |  | 11.36 |  | 6.36 | 2.26 | 0.0 |  |  |
| Qualcomm | MIL (dB) | 158.4 |  | 154.5 | 152.9 | 154.9 |  |  |  | 143.8 | 141.3 | 143.8 |  | 141.3 |
| Margin (dB) | 17.1 |  | 13.2 | 11.6 | 13.6 |  |  |  | 2.5 | 0.0 | 2.5 |  |  |
| Intel | MIL (dB) | 161.6 | 161.6 | 158.3 | 162.7 | 160.1 | 160.4 | 154.4 | 154.7 | 152.0 | 146.7 | 149.6 | 152.3 | 146.7 |
| Margin (dB) | 14.9 | 14.9 | 11.6 | 16.0 | 13.4 | 13.7 | 7.7 | 8.0 | 5.3 | 0.0 | 2.8 | 5.6 |  |

**Table 3.2-2: Link budget performance for the RedCap UE (20MHz BW, 2Rx)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Rural 700MHz, 2Rx RedCap UE** | | | | | | | | | | | | | | |
|  |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22bits | PUSCH | Msg3 | PRACH | Target /Option3 |
| Samsung | MIL (dB) | 159.4 | 159.4 | 154.9 | 154.9 | 155.9 |  | 155.3 | 151.5 | 148.5 | 143.6 | 146.5 |  | 146.6 |
| Margin (dB) | 12.9 | 12.9 | 8.4 | 8.4 | 9.4 |  | 8.7 | 4.9 | 1.9 | -3.0 | -0.1 |  |  |
| ZTE | MIL (dB) |  |  |  |  |  |  | 149.6 | 147.6 | 144.9 | 140.6 | 140.2 |  | 143.2 |
| Margin (dB) |  |  |  |  |  |  | 6.4 | 4.4 | 1.7 | -2.6 | -3.0 |  |  |
| OPPO | MIL (dB) | 160.1 | 160.1 | 159.0 | 154.0 | 158.0 |  | 146.0 | 146.1 | 145.9 | 147.0 | 146.5 |  | 148.9 |
| Margin (dB) | 11.2 | 11.2 | 10.0 | 5.0 | 9.1 |  | -2.9 | -2.8 | -3.0 | -1.9 | -2.5 |  |  |
| CATT | MIL (dB) | 155.4 | 155.4 | 152.8 | 150.5 | 153.8 |  | 153.6 | 152.4 | 150.3 | 144.9 | 147.7 |  | 147.9 |
| Margin (dB) | 7.5 | 7.5 | 4.9 | 2.6 | 5.9 |  | 5.6 | 4.5 | 2.4 | -3.1 | -0.3 |  |  |
| vivo | MIL (dB) | 152.0 | 152.1 | 149.0 | 146.8 | 149.7 | 156.2 | 147.3 | 144.4 | 142.0 | 141.0 | 143.3 | 142.7 | 144.0 |
| Margin (dB) | 8.0 | 8.1 | 5.0 | 2.8 | 5.8 | 12.2 | 3.3 | 0.5 | -1.9 | -3.0 | -0.7 | -1.3 |  |
| Xiaomi | MIL (dB) | 157.0 | 157.0 | 154.6 | 151.9 | 155.1 |  | 155.0 | 152.4 | 149.9 | 146.7 | 147.9 |  | 149.7 |
| Margin (dB) | 7.3 | 7.3 | 4.9 | 2.2 | 5.4 |  | 5.3 | 2.7 | 0.2 | -3.0 | -1.8 |  |  |
| Futurewei | MIL (dB) | 158.1 | 158.1 | 155.1 | 154.9 | 156.1 |  |  |  |  | 147.8 | 150.0 |  | 150.8 |
| Margin (dB) | 7.4 | 7.4 | 4.4 | 4.2 | 5.4 |  |  |  |  | -3.0 | -0.8 |  |  |
| Nokia | MIL (dB) | 155.0 | 155.0 | 156.5 | 153.7 | 156.4 |  | 141.9 |  | 140.7 | 141.2 | 135.5 | 144.9 | 138.5 |
| Margin (dB) | 16.5 | 16.5 | 18.0 | 15.1 | 17.9 |  | 3.4 |  | 2.2 | 2.6 | -3.0 | 6.4 |  |
| DOCOMO | MIL (dB) |  |  |  |  |  |  | 152.9 | 158.2 |  | 143.7 | 146.5 |  | 146.7 |
| Margin (dB) |  |  |  |  |  |  | 6.2 | 11.6 |  | -3.0 | -0.2 |  |  |
| Panasonic | MIL (dB) |  | 158.8 | 148.8 |  |  |  | 149.6 | 147.2 | 143.2 | 138.8 | 141.6 |  | 141.8 |
| Margin (dB) |  | 17.0 | 7.0 |  |  |  | 7.8 | 5.4 | 1.4 | -3.0 | -0.2 |  |  |
| Huawei | MIL (dB) | 154.2 | 154.2 | 149.9 | 149.9 | 150.6 |  | 149.8 |  | 147.6 | 138.8 | 142.3 |  | 141.8 |
| Margin (dB) | 12.5 | 12.5 | 8.1 | 8.1 | 8.8 |  | 8.0 |  | 5.8 | -3.0 | 0.5 |  |  |
| Spreadtrum | MIL (dB) | 158.0 | 158.0 | 156.0 | 157.0 | 157.0 | 160.0 | 157.5 | 154.5 | 154.3 | 148.5 | 151.5 | 153.8 | 151.5 |
| Margin (dB) | 6.6 | 6.6 | 4.6 | 5.6 | 5.6 | 8.6 | 6.0 | 3.0 | 2.8 | -3.0 | 0.0 | 2.4 |  |
| Apple | MIL (dB) | 154.7 | 154.7 | 152.9 | 148.5 | 152.7 |  |  |  |  | 140.7 |  |  | 143.7 |
| Margin (dB) | 11.0 | 11.0 | 9.2 | 4.8 | 9.0 |  |  |  |  | -3.0 |  |  |  |
| Ericsson | MIL (dB) | 154.3 | 153.6 | 149.0 | 150.2 | 152.9 | 154.3 | 146.4 | 154.9 | 144.4 | 139.9 | 142.0 | 144.9 | 142.9 |
| Margin (dB) | 11.5 | 10.8 | 6.2 | 7.4 | 10.1 | 11.5 | 3.5 | 12.0 | 1.5 | -3.0 | -0.9 | 2.1 |  |
| InterDigital | MIL (dB) | 158.2 | 158.2 | 155.52 | 149.31 | 152.16 |  | 152.8 |  | 147.8 | 143.7 | 141.44 |  | 144.44 |
| Margin (dB) | 13.76 | 13.76 | 11.08 | 4.87 | 7.72 |  | 8.36 |  | 3.36 | -0.74 | -3.0 |  |  |
| Qualcomm | MIL (dB) | 155.4 |  | 151.5 | 149.9 | 151.9 |  |  |  | 140.8 | 138.3 | 140.8 |  | 141.3 |
| Margin (dB) | 14.1 |  | 10.2 | 8.6 | 10.6 |  |  |  | -0.5 | -3.0 | -0.5 |  |  |
| Intel | MIL (dB) |  |  |  |  |  |  | 151.4 | 151.7 | 149.0 | 143.7 | 146.6 | 149.3 | 146.7 |
| Margin (dB) |  |  |  |  |  |  | 4.7 | 5.0 | 2.3 | -3.0 | -0.2 | 2.6 |  |

**Table 3.2-3: Link budget performance for the RedCap UE (20MHz BW, 1Rx)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Rural 700MHz, 1Rx RedCap UE** | | | | | | | | | | | | | | |
|  |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22bits | PUSCH | Msg3 | PRACH | Target /Option3 |
| Samsung | MIL (dB) | 155.7 | 155.7 | 150.6 | 149.0 | 152.2 |  | 155.3 | 151.5 | 148.5 | 143.6 | 146.5 |  | 146.6 |
| Margin (dB) | 9.2 | 9.2 | 4.1 | 2.5 | 5.7 |  | 8.7 | 4.9 | 1.9 | -3.0 | -0.1 |  |  |
| ZTE | MIL (dB) | 148.3 | 152.0 | 149.7 | 146.5 | 146.7 |  | 149.6 | 147.6 | 144.9 | 140.6 | 140.2 |  | 143.2 |
| Margin (dB) | 5.1 | 8.8 | 6.5 | 3.3 | 3.5 |  | 6.4 | 4.4 | 1.7 | -2.6 | -3.0 |  |  |
| OPPO | MIL (dB) | 155.5 | 155.5 | 155.4 | 148.6 | 153.8 |  | 146.0 | 146.1 | 145.9 | 147.0 | 146.5 |  | 148.9 |
| Margin (dB) | 6.6 | 6.6 | 6.5 | -0.4 | 4.8 |  | -2.9 | -2.8 | -3.0 | -1.9 | -2.5 |  |  |
| CATT | MIL (dB) | 152.0 | 152.0 | 149.6 | 144.1 | 149.5 |  | 153.6 | 152.4 | 150.3 | 144.9 | 147.7 |  | 147.9 |
| Margin (dB) | 4.0 | 4.0 | 1.7 | -3.9 | 1.5 |  | 5.6 | 4.5 | 2.4 | -3.1 | -0.3 |  |  |
| vivo | MIL (dB) | 149.3 | 149.3 | 145.5 | 141.5 | 145.7 | 152.4 | 147.3 | 144.4 | 142.0 | 141.0 | 143.3 | 142.7 | 144.0 |
| Margin (dB) | 5.3 | 5.3 | 1.5 | -2.5 | 1.8 | 8.4 | 3.3 | 0.5 | -1.9 | -3.0 | -0.7 | -1.3 |  |
| Xiaomi | MIL (dB) | 153.6 | 153.6 | 150.5 | 146.2 | 150.6 |  | 155.0 | 152.4 | 149.9 | 146.7 | 147.9 |  | 149.7 |
| Margin (dB) | 3.9 | 3.9 | 0.8 | -3.5 | 0.9 |  | 5.3 | 2.7 | 0.2 | -3.0 | -1.8 |  |  |
| Futurewei | MIL (dB) | 154.2 | 154.2 | 150.9 | 149.0 | 153.1 |  |  |  |  | 147.8 | 150.0 |  | 150.8 |
| Margin (dB) | 3.5 | 3.5 | 0.1 | -1.7 | 2.4 |  |  |  |  | -3.0 | -0.8 |  |  |
| Nokia | MIL (dB) | 150.7 | 150.7 | 153.9 | 150.0 | 153.4 |  | 141.9 |  | 140.7 | 141.2 | 135.5 | 144.9 | 138.5 |
| Margin (dB) | 12.2 | 12.2 | 15.4 | 11.5 | 14.9 |  | 3.4 |  | 2.2 | 2.6 | -3.0 | 6.4 |  |
| DOCOMO | MIL (dB) | 156.2 | 156.2 | 150.9 | 145.8 | 150.8 |  | 152.9 | 158.2 |  | 143.7 | 146.5 |  | 146.7 |
| Margin (dB) | 9.5 | 9.5 | 4.2 | -0.9 | 4.1 |  | 6.2 | 11.6 |  | -3.0 | -0.2 |  |  |
| Panasonic | MIL (dB) |  | 155.9 | 145.1 |  |  |  | 149.6 | 147.2 | 143.2 | 138.8 | 141.6 |  | 141.8 |
| Margin (dB) |  | 14.1 | 3.3 |  |  |  | 7.8 | 5.4 | 1.4 | -3.0 | -0.2 |  |  |
| Huawei | MIL (dB) | 150.9 | 150.9 | 146.2 | 145.6 | 146.6 |  | 149.8 |  | 147.6 | 138.8 | 142.3 |  | 141.8 |
| Margin (dB) | 9.1 | 9.1 | 4.4 | 3.8 | 4.8 |  | 8.0 |  | 5.8 | -3.0 | 0.5 |  |  |
| Spreadtrum | MIL (dB) | 155.0 | 155.0 | 153.0 | 154.0 | 153.0 | 157.0 | 157.5 | 154.5 | 154.3 | 148.5 | 151.5 | 153.8 | 151.5 |
| Margin (dB) | 3.6 | 3.6 | 1.6 | 2.6 | 1.6 | 5.6 | 6.0 | 3.0 | 2.8 | -3.0 | 0.0 | 2.4 |  |
| Apple | MIL (dB) | 151.7 | 151.7 | 148.8 | 144.0 | 148.0 |  |  |  |  | 140.7 |  |  | 143.7 |
| Margin (dB) | 8.0 | 8.0 | 5.1 | 0.3 | 4.3 |  |  |  |  | -3.0 |  |  |  |
| Ericsson | MIL (dB) | 149.9 | 150.1 | 149.0 | 146.1 | 149.2 | 149.9 | 146.4 | 154.9 | 144.4 | 139.9 | 142.0 | 144.9 | 142.9 |
| Margin (dB) | 7.1 | 7.3 | 6.2 | 3.3 | 6.4 | 7.1 | 3.5 | 12.0 | 1.5 | -3.0 | -0.9 | 2.1 |  |
| InterDigital | MIL (dB) | 154.4 | 154.4 | 151.87 | 143.79 | 148.53 |  | 152.8 |  | 147.8 | 143.7 | 141.44 |  | 144.44 |
| Margin (dB) | 9.96 | 9.96 | 7.43 | -0.65 | 4.09 |  | 8.36 |  | 3.36 | -0.74 | -3.0 |  |  |
| Qualcomm | MIL (dB) | 151.6 |  | 148.1 | 145.4 | 148.5 |  |  |  | 140.8 | 138.3 | 140.8 |  | 141.3 |
| Margin (dB) | 10.3 |  | 6.8 | 4.1 | 7.2 |  |  |  | -0.5 | -3.0 | -0.5 |  |  |
| Intel | MIL (dB) | 154.6 | 154.6 | 151.9 | 156.4 | 153.6 | 157.4 | 151.4 | 151.7 | 149.0 | 143.7 | 146.6 | 149.3 | 146.7 |
| Margin (dB) | 7.9 | 7.9 | 5.2 | 9.7 | 6.9 | 10.7 | 4.7 | 5.0 | 2.3 | -3.0 | -0.2 | 2.6 |  |

**Question 3.2-1: Can the link budget evaluation results in Table 3.2-1 to Table 3.2-3 be captured to TR 38.875? (Companies are invited to check the result and if any modification is needed, please also indicate here.)**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo |  | If possible, it would be useful to clarify the assumption in the simulation   1. For PRACH, the simulated format 2. For MSG2, whether existing TBS scaling is used? |
| ZTE | Y | Fine to capture the tables into the TR. |
| Qualcomm | Y | We support company to clarify whether TBS scaling is used for Msg2 evaluation. It may be difficult to derive this information from the spreadsheet since the use of a large number of PRB may be also for large payload of Msg2. However, we don’t think there is a need to split the tables for Msg2 with and without TBS scaling. |
| Nokia, NSB | Y |  |
| Futurewei |  | Same as 3.1-1 |
| NTT DOCOMO | Y |  |
| Ericsson | Y |  |
| CATT | Y |  |
| Intel | Y | Fine to capture the tables into TR. Fine to clarify PRACH format and TBS scaling for msg2. |
| Samsung |  | For Msg 2, it should be clarified whether or not Rel-15 TBS scaling was applied for each simulation result. |
| InterDigital | Y | We have provide some update on our results. |
| FL4 | Majority of responses are fine with capturing the above link budget evaluation results to TR 38.875. One response suggests the results can be captured in an Appendix of TR 38.875 by replacing company names with “source N”. Several responses comment to clarify evaluation assumption for msg2 and PRACH.  For Msg2 results, some companies might have considered TBS scaling and some others have not. However, the assumption for TBS scaling is not available in the evaluation spreadsheet. FL suggests the sourcing companies to clarify whether TBS scaling is used for Msg2 and also PRACH format.  Based on the responses, FL makes the following proposal:  **[FL4] Proposal 3.2-1:**   * Capture the link budget evaluation results (Rural 0.7 GHz) in Table 3.2-1 to Table 3.2-3 to the Appendix of TR 38.875   + The tables will be further updated with potential updated coverage recovery evaluation results and a clarification of assumption for Msg2, and PRACH | |
| vivo |  | For MSG2, we use MCS#0 with no TBS scaling  For PRACH, only format 0 is captured according to the template. However, we believe for FDD, PRACH format 2 is possible for better coverage, therefore not proper to draw conclusion based on PRACH format 0 only. |
| Qualcomm |  | We are fine with the FL updated proposal  For Msg2, no TBS scaling is used (3 RBs, MCS0, and TBS = 9 bytes) |
| Huawei, Hisilicon | N | Similar comment as to Question 3.1-1. |
| Futurewei |  | No tbs scaling is used |
| Intel | Y | We simulate Msg2 with scaling factor 1/4 and PRACH format 0 |
| Ericsson |  | We are fine with the FL’s updated proposal.  Regarding TBS scaling for Msg2, we have provided results with and without TBS scaling. We suggest using results based on no TBS scaling as a baseline. TBS scaling can be considered as a coverage recovery technique for Msg2.  Regarding PRACH, our results are based on Format 0 (1.25 KHz SCS). |
| Samsung |  | No TBS scaling was used for Msg2. |
| CATT |  | For Msg2, we use MCS#0 with no TBS scaling. |
| Xiaomi |  | For Msg.2, we use MCS#0 w/o TBS scaling |
| ZTE |  | We are fine with the proposal.  For Msg.2, we use (3 RBs, MCS#0, TBS = 9 bytes) w/o TBS scaling. |
| InterDigital |  | For Msg2, we used 3 RBs, MCS0, 72 bits. |
| OPPO |  | For Msg2, we used 3 RBs, MCS0, without TBS scaling. |
| **FL5** | Based on the received responses, the FL’s updated suggestion is as following.  **[FL5] Updated Proposal 3.2-1:**   * Capture the link budget evaluation results (rural 0.7 GHz) in Table 3.2-1 to Table 3.2-3 to the Appendix of TR 38.875   + The tables will be further updated with potential updated evaluation results (to catch potential typos) and a clarification of assumption for Msg2 and PRACH.   + MPL results to be included also. Up to editor to use the same or different tables. | |
| Panasonic | Y |  |
| vivo | Y |  |

Based on the evaluation results in Table 3.2-1 to Table 3.2-3, the channels that potentially need coverage recovery in rural scenario at 0.7 GHz and the summary of companies evaluation results for the margin to the coverage recovery target (i.e. the MIL of bottleneck channel for the reference NR UE) are summarized in Table 3.2-4, where the numbers in bracket is the number of samples.

**Table 3.2-4: Coverage recovery for RedCap UE in rural scenario at 0.7 GHz (Option 3)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Channels | Mean | Median | Range | Representative value |
| 2Rx RedCap | PUSCH (17) | -2.6 | -3.0 | 5.7 | -2.9 |
| Msg3 (15) | -0.9 | -0.5 | 3.5 | -0.8 |
| PUCCH PF3 22 bits (14) | 1.3 | 1.6 | 8.8 | 1.3 |
| 1Rx RedCap | PUSCH (17) | -2.6 | -3.0 | 5.7 | -2.9 |
| Msg3 (15) | -0.9 | -0.5 | 3.5 | -0.8 |
| PUCCH PF3 with 22 bits (14) | 1.3 | 1.6 | 8.8 | 1.3 |
| Msg2 (15) | 1.9 | 2.5 | 15.4 | 1.6 |

**Question 3.2-2: Can Table 3.2-4 be captured to TR 38.875? If not, any other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| FL |  | Table 3.2-4 has been updated by considering all the companies’ evaluation results. The representative value in the table is expected to be updated based on the agreement for the coverage recovery target in section 2, and the positive representative value indicates the LB of the concerned channel is better than the MIL of the bottleneck channel of the reference NR UE. |
| vivo |  | The range for msg 2 is up to 15dB, which seems too large |
| ZTE |  | Similar comment as to Question 3.1-2. |
| Nokia, NSB |  | Similar comment as to Question 3.1-2 |
| Futurewei |  | Similar comment to 3.1-2. The range for msg2 may be higher due to different assumptions on the number of users etc. Also although higher range exists for PUCCH and Msg2, it seems most companies agree no compensation is needed for these two. |
| NTT DOCOMO |  | Similar comment as to Question 3.1-2. |
| Ericsson |  | We suggest clarifying (1) the meaning of the numbers in parentheses, and (2) how is the range computed (e.g., maximum-minimum). |
| CATT | Y | Similar comment as to Question 3.1-2 |
| Intel |  | The table can be formed after proposal is section 2 is finalized. |
| Samsung |  | For some DL channel, a big gap (e.g., 15.4dB for Msg 2) between companies is observed. Before capturing the results, some clarification and analysis on the big gap are necessary. |
| Huawei, Hisilicon | N | We prefer to wait until proposal 1 is agreed. |
| Xiaomi |  | It would be better to wait for more stable proposal 1 |

Based on the results in Table 3.2-4, the following observations are proposed for discussion for the TP drafting for TR 38.875.

[FL notes: The observations will be updated based on the agreement for the coverage recovery target in section 2 and the update of Table 3.2-4]

**Moderator’s observation**

* P1: For RedCap UE in rural scenario at 0.7 GHz, three UL channels, PUSCH, Msg3, PUCCH format 3 with 22 bits do not reach the target coverage requirement and need for coverage recovery
  + A compensation of approximately 3 dB, 1.1 dB and 1.8 dB respectively, is observed for PUSCH, Msg3 and PUCCH format 3 with 22 bits
* P2: Compared to the target coverage requirement, a coverage degradation of approximately 2.8 dB and 1.3 dB respectively, is observed for PUCCH format 3 with 11 bits and PRACH format 0 by one source company
* P3: For a RedCap UE with 2 Rx antenna at 0.7 GHz carrier frequency, all downlink channels can reach the target coverage requirement thus requiring no compensation
* P4: For a RedCap UE with 1 Rx antenna at 0.7 GHz carrier frequency, all downlink channels except for Msg2 can reach the target coverage requirement thus requiring no compensation
  + A coverage compensation of approximately 2.1 dB is observed for Msg2 PDSCH

**Question 3.2-3: Can the above list (P1-P4) be used as a baseline text for TR 38.875? If not, what other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | N | Prefer to wait until proposal 1 is stable/agreed |
| Nokia, NSB |  | We prefer to wait until proposal 1 is agreed |
| Ericsson |  | P1: The conclusion that PUCCH format 3 with 22 bits needs more compensation than Msg3 is a bit problematic. Note that results from most companies do not indicate compensation is needed at all for PUCCH format 3 with 22 bits. We suggest stating the observation on PUCCH format 3 with 22 bits in a separate statement and clarifying that this observation is derived based on only 3 sourcing companies. Furthermore, in our view 22-bit PUCCH could be an overkill for a baseline RedCap UE in FR1 considering it does not need to support CA (possibly no MIMO support either).  For PUSCH, it can be clarified the 3 dB coverage compensation is needed if the target data rate for RedCap UEs is the same as reference UE. We should add a note here to state that the 3 dB coverage compensation is not needed if the target data rate for RedCap UEs is reduced.  We can further mention that the 3 dB loss is resulting from the UE antenna efficiency loss assumed for the wearable use cases only.  P4: it should be emphasized that this is based on results from 6 sourcing companies while all other sourcing companies indicate that Msg2 does not need coverage compensation.  As we have commented in replying to Question 2-1, perhaps we should consider determining the “*representative value of the amount of compensation*” based on both positive and negative values. |
| CATT |  | Generally fine with the observation. Also OK to wait until further progress of proposal 1 is made. |
| Samsung |  | It can be mentioned that 3dB antenna loss is resulted from reduced antenna efficiency due to device size limitations for wearables.  Some note for Msg 2 in the below P4 can be clarified. If TBS scaling for Msg 2 is not assumed in the simulation results, the following note as for exmaple is suggested in the below P4 given the TBS scaling is already supported in Rel-15:  Note that TBS scaling for Msg 2 has not been considered in the evaluation, which could provide some gain for Msg 2. |

**[FL5] Based on the received responses, the FL’s updated text proposal is as following.**

**(FL note: based on the outcome of Proposal 2-1, some numbers in the tables can be further updated, however, the conclusion is expected to be same)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| For rural scenario at 0.7 GHz, the bottleneck channel for the reference NR UE and the corresponding maximum isotropic loss (MIL) value by the sourcing companies are shown in Table 9.1-4. The estimated coverage loss for the RedCap UE in rural scenario at 0.7 GHz, relative to the bottleneck channel of the reference NR UE is summarized in Table 9.1-5 and Table 9.1-6. It is noted that the 3dB antenna efficiency loss is assumed in both DL and UL for the RedCap UE.  **Table 9.1-4: Bottleneck channel and MIL value for Reference NR UE in rural 0.7 GHz**   |  |  |  | | --- | --- | --- | |  | Bottleneck Channel | MIL (dB) | | Samsung | PUSCH | 146.6 | | ZTE | Msg3 | 143.2 | | OPPO | PUCCH PF3 22 bits | 148.9 | | CATT | PUSCH | 147.9 | | vivo | PUSCH | 144.0 | | Xiaomi | PUSCH | 149.7 | | Futurewei | PUSCH | 150.8 | | Nokia | Msg3 | 138.5 | | DCM | PUSCH | 146.7 | | Panasonic | PUSCH | 141.8 | | Huawei | PUSCH | 141.8 | | SPRD | PUSCH | 151.5 | | Apple | PUSCH | 143.7 | | Ericsson | PUSCH | 142.9 | | IDCC | Msg3 | 144.4 | | QC | PUSCH | 141.3 | | Intel | PUSCH | 146.7 |   The representative values in the last row of Table 9.1-5 and Table 9.1-6 are derived by taking the mean value (in dB domain) from all the companies results and excluding the highest and the lowest values when the number of samples is more than 3. A negative value of the representative value for a channel of the RedCap UE indicates the coverage of the channel is worse than that of the bottleneck channel of the reference NR UE and coverage recovery is needed.  As can be seen in the last row for the representative value, all the channels except for PUSCH and Msg3 have better coverage than that of the bottleneck channel thus requiring no compensation. On average, a coverage degradation of approximately 2.8 dB and 1 dB, respectively is observed for PUSCH and Msg3.  It should be noted that the 3 dB loss is resulted from the UE antenna efficiency loss assumed for the wearable use cases. Furthermore, the same target data rate of 100 kbps for PUSCH is assumed for both RedCap UE and the reference NR UE (see evaluation methodology described in clause 6.3). A smaller coverage loss for PUSCH is expected if the target data rate for RedCap UE is reduced.  **Table 9.1-5: Coverage loss (dB) for 2Rx RedCap UE in rural scenario at 0.7 GHz (Option 3)**   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22 bits | PUSCH | Msg3 | PRACH | | Samsung | 12.9 | 12.9 | 8.4 | 8.4 | 9.4 |  | 8.7 | 4.9 | 1.9 | -3.0 | -0.1 |  | | ZTE |  |  |  |  |  |  | 6.4 | 4.4 | 1.7 | -2.6 | -3.0 |  | | OPPO | 11.2 | 11.2 | 10.0 | 5.0 | 9.1 |  | -2.9 | -2.8 | -3.0 | -1.9 | -2.5 |  | | CATT | 7.5 | 7.5 | 4.9 | 2.6 | 5.9 |  | 5.6 | 4.5 | 2.4 | -3.1 | -0.3 |  | | vivo | 8.0 | 8.1 | 5.0 | 2.8 | 5.8 | 12.2 | 3.3 | 0.5 | -1.9 | -3.0 | -0.7 | -1.3 | | Xiaomi | 7.3 | 7.3 | 4.9 | 2.2 | 5.4 |  | 5.3 | 2.7 | 0.2 | -3.0 | -1.8 |  | | Futurewei | 7.4 | 7.4 | 4.4 | 4.2 | 5.4 |  |  |  |  | -3.0 | -0.8 |  | | Nokia | 16.5 | 16.5 | 18.0 | 15.1 | 17.9 |  | 3.4 |  | 2.2 | 2.6 | -3.0 | 6.4 | | DCM |  |  |  |  |  |  | 6.2 | 11.6 |  | -3.0 | -0.2 |  | | Panasonic |  | 17.0 | 7.0 |  |  |  | 7.8 | 5.4 | 1.4 | -3.0 | -0.2 |  | | Huawei | 12.5 | 12.5 | 8.1 | 8.1 | 8.8 |  | 8.0 |  | 5.8 | -3.0 | 0.5 |  | | SPRD | 6.6 | 6.6 | 4.6 | 5.6 | 5.6 | 8.6 | 6.0 | 3.0 | 2.8 | -3.0 | 0.0 | 2.4 | | Apple | 11.0 | 11.0 | 9.2 | 4.8 | 9.0 |  |  |  |  | -3.0 |  |  | | Ericsson | 11.5 | 10.8 | 6.2 | 7.4 | 10.1 | 11.5 | 3.5 | 12.0 | 1.5 | -3.0 | -0.9 | 2.1 | | IDCC | 13.8 | 13.8 | 11.1 | 4.9 | 7.7 |  | 8.4 |  | 3.4 | -0.7 | -3.0 |  | | QC | 14.1 |  | 10.2 | 8.6 | 10.6 |  |  |  | -0.5 | -3.0 | -0.5 |  | | Intel\* |  |  |  |  |  |  | 4.7 | 5.0 | 2.3 | -3.0 | -0.2 | 2.6 | | Representative value (dB) | **10.6** | **10.8** | **7.5** | **5.7** | **7.9** | **11.5** | **5.7** | **4.7** | **1.4** | **-2.8** | **-1.0** | **2.3** |   Note: A TBS scaling factor ¼ is assumed for Msg2 evaluation  **Table 9.1-6: Coverage loss (dB) for 1Rx RedCap UE in rural scenario at 0.7 GHz (Option 3)**   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22 bits | PUSCH | Msg3 | PRACH | | Samsung | 9.2 | 9.2 | 4.1 | 2.5 | 5.7 |  | 8.7 | 4.9 | 1.9 | -3.0 | -0.1 |  | | ZTE | 5.1 | 8.8 | 6.5 | 3.3 | 3.5 |  | 6.4 | 4.4 | 1.7 | -2.6 | -3.0 |  | | OPPO | 6.6 | 6.6 | 6.5 | -0.4 | 4.8 |  | -2.9 | -2.8 | -3.0 | -1.9 | -2.5 |  | | CATT | 4.0 | 4.0 | 1.7 | -3.9 | 1.5 |  | 5.6 | 4.5 | 2.4 | -3.1 | -0.3 |  | | vivo | 5.3 | 5.3 | 1.5 | -2.5 | 1.8 | 8.4 | 3.3 | 0.5 | -1.9 | -3.0 | -0.7 | -1.3 | | Xiaomi | 3.9 | 3.9 | 0.8 | -3.5 | 0.9 |  | 5.3 | 2.7 | 0.2 | -3.0 | -1.8 |  | | Futurewei | 3.5 | 3.5 | 0.1 | -1.7 | 2.4 |  |  |  |  | -3.0 | -0.8 |  | | Nokia | 12.2 | 12.2 | 15.4 | 11.5 | 14.9 |  | 3.4 |  | 2.2 | 2.6 | -3.0 | 6.4 | | DCM | 9.5 | 9.5 | 4.2 | -0.9 | 4.1 |  | 6.2 | 11.6 |  | -3.0 | -0.2 |  | | Panasonic |  | 14.1 | 3.3 |  |  |  | 7.8 | 5.4 | 1.4 | -3.0 | -0.2 |  | | Huawei | 9.1 | 9.1 | 4.4 | 3.8 | 4.8 |  | 8.0 |  | 5.8 | -3.0 | 0.5 |  | | SPRD | 3.6 | 3.6 | 1.6 | 2.6 | 1.6 | 5.6 | 6.0 | 3.0 | 2.8 | -3.0 | 0.0 | 2.4 | | Apple | 8.0 | 8.0 | 5.1 | 0.3 | 4.3 |  |  |  |  | -3.0 |  |  | | Ericsson | 7.1 | 7.3 | 6.2 | 3.3 | 6.4 | 7.1 | 3.5 | 12.0 | 1.5 | -3.0 | -0.9 | 2.1 | | IDCC | 10.0 | 10.0 | 7.4 | -0.7 | 4.1 |  | 8.4 |  | 3.4 | -0.7 | -3.0 |  | | QC | 10.3 |  | 6.8 | 4.1 | 7.2 |  |  |  | -0.5 | -3.0 | -0.5 |  | | Intel\* | 7.9 | 7.9 | 5.2 | 9.7 | 6.9 | 10.7 | 4.7 | 5.0 | 2.3 | -3.0 | -0.2 | 2.6 | | Representative value (dB) | **7.1** | **7.5** | **4.4** | **1.4** | **4.2** | **7.8** | **5.7** | **4.7** | **1.4** | **-2.8** | **-1.0** | **2.3** |   Note: A TBS scaling factor ¼ is assumed for Msg2 evaluation |

**[FL5] Question 3.2-1A:** **Can the above observations of the relative coverage loss be used as a baseline text for TR 38.875? If not, what aspects to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Panasonic | Y |  |
| vivo |  | It would be useful to make if clear   * + - 1. All companies except one company does not apply TBS scaling for MSG2       2. PRACH format 0 is simulated |
|  |  |  |

## FR1, Urban with the carrier frequency of 4 GHz

Based on the latest available evaluation results in [RedCapCoverage-4GHz-v014](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/drafts/8.6/EvaluationResults/RedCapCoverage/4GHz/RedCapCoverage-4GHz-v014.xlsx), the link budget performance for both the reference UE and RedCap UE in Urban scenario at 2.6GHz is summarized in Table 3.3-1 to Table 3.3-3 (Company please double check whether your results are correctly captured in these tables. We have found there are some mismatch between the spreadsheet and the contribution for some companies results).

In the link budget tables, the maximum isotropic loss (MIL) is used as the coverage evaluation metric and for each channel the margin to the target performance is also shown, where the target performance is a company specific value and derived based on the link budget of the bottleneck channel for the reference NR UE (i.e. Option 3). The coverage limiting channel for RedCap UE, e.g. the link budget for the channel worse than that target performance, is highlighted with RED.

**Table 3.3-1: Link budget performance for the reference NR UE (100MHz BW, 4Rx)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Urban, 4GHz, 4Rx Ref NR UE** | | | | | | | | | | | | | | |
|  |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22bits | PUSCH | Msg3 | PRACH | Target /Option3 |
| Samsung | MIL (dB) | 165.9 | 170.1 | 162.6 | 162.3 | 162.4 |  | 158.6 | 154.8 | 151.9 | 142.0 | 150.0 |  | 142.0 |
| Margin (dB) | 23.8 | 28.0 | 20.5 | 20.2 | 20.3 |  | 16.6 | 12.8 | 9.9 | 0.0 | 8.0 |  |  |
| ZTE | MIL (dB) | 147.8 | 158.2 | 157.3 | 148.3 | 148.6 |  | 162.6 | 160.9 | 158.3 | 143.0 | 156.3 |  | 143.0 |
| Margin (dB) | 4.8 | 15.2 | 14.3 | 5.3 | 5.5 |  | 19.6 | 17.9 | 15.3 | 0.0 | 13.3 |  |  |
| OPPO | MIL (dB) | 158.5 | 162.5 | 158.9 | 153.4 | 156.2 |  | 155.0 | 155.0 | 155.2 | 147.0 | 154.7 |  | 147.0 |
| Margin (dB) | 11.4 | 15.4 | 11.9 | 6.4 | 9.2 |  | 8.0 | 8.0 | 8.2 | 0.0 | 7.7 |  |  |
| vivo | MIL (dB) | 157.7 | 165.7 | 161.9 | 157.1 | 158.6 | 160.8 | 156.3 | 153.8 | 151.0 | 139.3 | 152.3 | 149.6 | 139.3 |
| Margin (dB) | 18.4 | 26.4 | 22.6 | 17.8 | 19.3 |  | 17.0 | 14.5 | 11.8 | 0.0 | 13.0 | 10.3 |  |
| Futurewei | MIL (dB) | 155.9 | 157.9 | 156.0 | 153.0 | 155.1 |  |  |  |  | 152.6 | 153.5 |  | 152.6 |
| Margin (dB) | 3.2 | 5.2 | 3.3 | 0.3 | 2.4 |  | -152.6 | -152.6 | -152.6 | 0.0 | 0.9 |  |  |
| Nokia | MIL (dB) | 168.4 | 168.4 | 165.3 | 168.8 | 165.9 |  | 151.7 |  | 150.2 | 140.8 | 147.3 | 155.1 | 140.8 |
| Margin (dB) | 27.6 | 27.6 | 24.5 | 28.0 | 25.1 |  | 10.9 | -140.8 | 9.4 | 0.0 | 6.5 | 14.3 |  |
| DOCOMO | MIL (dB) | 156.8 | 160.8 | 157.5 | 151.5 | 153.6 |  | 161.2 | 164.8 |  | 146.8 | 154.6 |  | 146.8 |
| Margin (dB) | 10.0 | 14.0 | 10.7 | 4.7 | 6.8 |  | 14.5 | 18.1 | -146.8 | 0.0 | 7.9 |  |  |
| Huawei | MIL (dB) | 164.0 | 168.0 | 164.2 | 161.1 | 160.9 |  | 160.5 |  | 158.8 | 140.0 | 149.7 |  | 140.0 |
| Margin (dB) | 24.0 | 28.0 | 24.2 | 21.1 | 20.8 |  | 20.5 | -140.0 | 18.7 | 0.0 | 9.6 |  |  |
| Spreadtrum | MIL (dB) | 155.8 | 160.0 | 157.8 | 154.8 | 154.8 | 157.8 | 158.2 | 156.2 | 158.0 | 145.4 | 153.5 | 155.6 | 145.4 |
| Margin (dB) | 10.3 | 14.5 | 12.3 | 9.3 | 9.3 |  | 12.8 | 10.8 | 12.6 | 0.0 | 8.1 | 10.1 |  |
| Ericsson | MIL (dB) | 149.0 | 153.0 | 149.7 | 143.6 | 146.5 | 150.9 | 153.6 | 155.5 | 153.6 | 144.0 | 151.3 | 154.9 | 143.6 |
| Margin (dB) | 5.4 | 9.4 | 6.1 | 0.0 | 2.9 |  | 10.0 | 12.0 | 10.1 | 0.5 | 7.7 | 11.3 |  |
| InterDigital | MIL (dB) | 155.47 | 159.5 | 157.13 | 160.42 | 162.55 |  | 160.6 |  | 156.6 | 144.9 | 152.87 |  | 144.9 |
| Margin (dB) | 10.57 | 14.6 | 12.23 | 15.52 | 17.65 |  | 15.7 |  | 11.7 | 0.0 | 7.97 |  |  |
| Qualcomm | MIL (dB) | 152.3 |  | 151.3 | 147.1 | 148.6 |  |  |  | 146.5 | 140.7 | 154.1 |  | 140.7 |
| Margin (dB) | 11.6 | -140.7 | 10.6 | 6.4 | 7.9 |  |  |  | 5.8 | 0.0 | 13.4 |  |  |
| Intel | MIL (dB) | 156.3 | 157.4 | 152.7 | 157.0 | 154.7 | 156.3 | 161.5 | 160.3 | 157.7 | 140.0 | 147.0 | 156.3 | 140.0 |
| Margin (dB) | 16.3 | 17.4 | 12.7 | 17.0 | 14.7 |  | 21.5 | 20.3 | 17.7 | 0.0 | 7.0 | 16.3 |  |
| Lenovo, Motorola Mobility | MIL (dB) | 157.8 |  | 152.5 | 153.1 | 156.0 |  | 163.0 | 158.2 | 154.0 | 148.3 | 154.2 |  | 148.3 |
| Margin (dB) | 9.5 |  | 4.2 | 4.8 | 7.7 |  | 14.7 | 9.9 | 5.7 | 0 | 5.9 |  |  |

**Table 3.3-2: Link budget performance for the RedCap UE (20MHz BW, 2Rx)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Urban, 4GHz, 2Rx RedCap UE** | | | | | | | | | | | | | | |
|  |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22bits | PUSCH | Msg3 | PRACH | Target /Option3 |
| Samsung | MIL (dB) | 160.1 | 164.1 | 156.9 | 155.8 | 156.8 |  | 155.3 | 151.5 | 148.5 | 139.0 | 147.0 |  | 142.0 |
| Margin (dB) | 18.0 | 22.0 | 14.8 | 13.7 | 14.7 |  | 13.3 | 9.5 | 6.5 | -3.0 | 5.0 |  |  |
| OPPO | MIL (dB) | 152.2 | 156.2 | 154.5 | 146.3 | 150.0 |  | 151.9 | 152.0 | 151.9 | 144.0 | 151.7 |  | 147.0 |
| Margin (dB) | 5.1 | 9.1 | 7.5 | -0.7 | 3.0 |  | 4.9 | 5.0 | 4.9 | -3.0 | 4.7 |  |  |
| vivo | MIL (dB) | 152.0 | 160.0 | 155.2 | 149.6 | 151.5 | 155.3 | 153.3 | 150.8 | 148.0 | 136.4 | 149.6 | 146.6 | 139.3 |
| Margin (dB) | 12.7 | 20.7 | 16.0 | 10.3 | 12.3 | 16.0 | 14.0 | 11.5 | 8.8 | -2.8 | 10.3 | 7.3 |  |
| Futurewei | MIL (dB) | 150.3 | 152.3 | 150.1 | 146.3 | 149.1 |  |  |  |  | 149.6 | 150.5 |  | 152.6 |
| Margin (dB) | -2.4 | -0.4 | -2.6 | -6.4 | -3.6 |  |  |  |  | -3.0 | -2.1 |  |  |
| Nokia | MIL (dB) | 162.5 | 162.5 | 158.6 | 163.4 | 160.0 |  | 148.7 |  | 147.2 | 137.8 | 144.3 | 152.1 | 140.8 |
| Margin (dB) | 21.7 | 21.7 | 17.8 | 22.6 | 19.2 |  | 7.9 |  | 6.4 | -3.0 | 3.5 | 11.3 |  |
| DOCOMO | MIL (dB) | 150.9 | 154.9 | 150.8 | 143.9 | 147.0 |  | 158.2 | 161.8 |  | 143.8 | 151.6 |  | 146.8 |
| Margin (dB) | 4.1 | 8.1 | 4.0 | -2.8 | 0.2 |  | 11.5 | 15.1 |  | -3.0 | 4.9 |  |  |
| Huawei | MIL (dB) | 158.0 | 162.0 | 156.9 | 154.7 | 154.6 |  | 157.5 |  | 155.8 | 137.0 | 146.7 |  | 140.0 |
| Margin (dB) | 18.0 | 22.0 | 16.9 | 14.6 | 14.6 |  | 17.5 |  | 15.7 | -3.0 | 6.6 |  |  |
| Spreadtrum | MIL (dB) | 149.8 | 154.0 | 151.8 | 148.8 | 148.8 | 151.8 | 155.2 | 153.2 | 155.0 | 142.4 | 150.5 | 152.6 | 145.4 |
| Margin (dB) | 4.3 | 8.5 | 6.3 | 3.3 | 3.3 | 6.3 | 9.8 | 7.8 | 9.6 | -3.0 | 5.1 | 7.1 |  |
| Ericsson | MIL (dB) | 142.8 | 146.8 | 143.5 | 137.2 | 139.9 | 145.0 | 150.6 | 152.5 | 150.6 | 141.0 | 148.3 | 151.9 | 143.6 |
| Margin (dB) | -0.8 | 3.2 | -0.1 | -6.4 | -3.7 | 1.4 | 7.0 | 9.0 | 7.1 | -2.5 | 4.7 | 8.3 |  |
| InterDigital | MIL (dB) | 149.77 | 153.8 | 151.30 | 153.83 | 156.80 |  | 157.1 |  | 152.8 | 141.9 | 149.87 |  | 144.9 |
| Margin (dB) | 4.87 | 8.9 | 6.4 | 8.93 | 11.9 |  | 12.2 |  | 7.9 | -3.0 | 4.97 |  |  |
| Qualcomm | MIL (dB) | 146.8 |  | 145.6 | 140.8 | 143.1 |  |  |  | 143.5 | 137.0 | 144.0 |  | 140.7 |
| Margin (dB) | 6.1 |  | 4.9 | 0.1 | 2.4 |  |  |  | 2.8 | -3.7 | 3.3 |  |  |
| Intel | MIL (dB) | 150.4 | 151.5 | 146.5 | 151.4 | 148.6 | 153.3 | 158.5 | 157.3 | 154.7 | 137.7 | 151.1 | 153.3 | 140.0 |
| Margin (dB) | 10.4 | 11.5 | 6.5 | 11.4 | 8.6 | 13.3 | 18.5 | 17.3 | 14.7 | -2.3 | 11.2 | 13.3 |  |

**Table 3.3-3: Link budget performance for the RedCap UE (20MHz BW, 1Rx)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Urban, 4GHz, 1Rx RedCap UE** | | | | | | | | | | | | | | |
|  |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22bits | PUSCH | Msg3 | PRACH | Target /Option3 |
| Samsung | MIL (dB) | 156.6 | 160.6 | 152.2 | 150.6 | 153.2 |  | 155.3 | 151.5 | 148.5 | 139.0 | 147.0 |  | 142.0 |
| Margin (dB) | 14.5 | 18.5 | 10.1 | 8.5 | 11.1 |  | 13.3 | 9.5 | 6.5 | -3.0 | 5.0 |  |  |
| ZTE | MIL (dB) | 138.6 | 149.0 | 151.6 | 141.7 | 141.9 |  | 159.6 | 157.9 | 155.3 | 140.0 | 153.3 |  | 143.0 |
| Margin (dB) | -4.5 | 6.0 | 8.6 | -1.3 | -1.1 |  | 16.6 | 14.9 | 12.3 | -3.0 | 10.3 |  |  |
| OPPO | MIL (dB) | 148.2 | 152.2 | 151.9 | 140.8 | 146.2 |  | 151.9 | 152.0 | 151.9 | 144.0 | 151.7 |  | 147.0 |
| Margin (dB) | 1.2 | 5.2 | 4.9 | -6.2 | -0.8 |  | 4.9 | 5.0 | 4.9 | -3.0 | 4.7 |  |  |
| vivo | MIL (dB) | 148.8 | 156.8 | 150.6 | 144.8 | 146.8 | 152.6 | 153.3 | 150.8 | 148.0 | 136.4 | 149.6 | 146.6 | 139.3 |
| Margin (dB) | 9.6 | 17.6 | 11.4 | 5.6 | 7.5 | 13.4 | 14.0 | 11.5 | 8.8 | -2.8 | 10.3 | 7.3 |  |
| Futurewei | MIL (dB) | 146.7 | 148.7 | 145.3 | 139.3 | 143.0 |  |  |  |  | 149.6 | 150.5 |  | 152.6 |
| Margin (dB) | -6.0 | -4.0 | -7.4 | -13.4 | -9.7 |  |  |  |  | -3.0 | -2.1 |  |  |
| Nokia | MIL (dB) | 158.5 | 158.5 | 154.8 | 159.6 | 156.5 |  | 148.7 |  | 147.2 | 137.8 | 144.3 | 152.1 | 140.8 |
| Margin (dB) | 17.7 | 17.7 | 14.0 | 18.8 | 15.7 |  | 7.9 |  | 6.4 | -3.0 | 3.5 | 11.3 |  |
| DOCOMO | MIL (dB) | 147.6 | 151.6 | 146.8 | 138.3 | 142.9 |  | 158.2 | 161.8 |  | 143.8 | 151.6 |  | 146.8 |
| Margin (dB) | 0.8 | 4.8 | 0.0 | -8.5 | -3.9 |  | 11.5 | 15.1 |  | -3.0 | 4.9 |  |  |
| Huawei | MIL (dB) | 154.5 | 158.5 | 153.1 | 150.4 | 150.8 |  | 157.5 |  | 155.8 | 137.0 | 146.7 |  | 140.0 |
| Margin (dB) | 14.5 | 18.5 | 13.0 | 10.3 | 10.7 |  | 17.5 |  | 15.7 | -3.0 | 6.6 |  |  |
| Spreadtrum | MIL (dB) | 146.8 | 151.0 | 148.8 | 145.8 | 145.8 | 148.8 | 155.2 | 153.2 | 155.0 | 142.4 | 150.5 | 152.6 | 145.4 |
| Margin (dB) | 1.3 | 5.5 | 3.3 | 0.3 | 0.3 | 3.3 | 9.8 | 7.8 | 9.6 | -3.0 | 5.1 | 7.1 |  |
| Ericsson | MIL (dB) | 139.7 | 143.8 | 139.8 | 132.4 | 136.0 | 141.4 | 150.6 | 152.5 | 150.6 | 141.0 | 148.3 | 151.9 | 143.6 |
| Margin (dB) | -3.9 | 0.2 | -3.8 | -11.2 | -7.6 | -2.2 | 7.0 | 9.0 | 7.1 | -2.5 | 4.7 | 8.3 |  |
| InterDigital | MIL (dB) | 146.57 | 150.6 | 148.23 | 149.29 | 153.67 |  | 157.1 |  | 152.8 | 141.9 | 149.87 |  | 144.9 |
| Margin (dB) | 1.67 | 5.7 | 3.33 | 4.39 | 8.77 |  | 12.2 |  | 7.9 | -3.0 | 4.97 |  |  |
| Qualcomm | MIL (dB) | 143.5 |  | 142.4 | 136.9 | 139.8 |  |  |  | 143.5 | 137.0 | 144.0 |  | 140.7 |
| Margin (dB) | 2.8 |  | 1.7 | -3.8 | -0.9 |  |  |  | 2.8 | -3.7 | 3.3 |  |  |
| Lenovo, Motorola Mobility | MIL (dB) | 146.3 |  | 145.7 | 140.2 | 145.4 |  | 160.0 | 155.2 | 154.0 | 145.3 | 151.2 |  | 148.3 |
| Margin (dB) | -2.0 |  | -2.6 | -8.1 | -2.9 |  | 11.7 | 6.9 | 5.7 | -3.0 | 2.9 |  |  |

**Question 3.3-1: Can the link budget evaluation results in Table 3.3-1 to Table 3.3-3 be captured to TR 38.875? (Companies are invited to check the results and if any modification is needed, please also indicate here.)**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo |  | If possible, it would be useful to clarify the assumption in the simulation   1. For PRACH, the simulated format 2. For MSG2, whether existing TBS scaling is used? 3. The assumed DL PSD, 24dBm/MHz, or 33dBm/MHz |
| ZTE | Y | Fine to capture the tables into the TR. |
| Qualcomm | Y | We don’t support to split the tables based on DL PSD values since the insufficient number of samples is difficult to make a decision. |
| Nokia, NSB | Y |  |
| Futurewei |  | Same as above |
| NTT DOCOMO | Y |  |
| Ericsson |  | Some evaluations are based on downlink power spectrum density 24 dBm/MHz, whereas some are based on 33 dBm/MHz. It might be better to have separate tables for the two different power spectrum density settings.  Also for Msg2 results, some companies might have considered TBS scaling and some others have not. Could the sourcing companies clarify whether TBS scaling is used for Msg2. Ericsson will update our results to include performance with and without TBS scaling. |
| Intel | Y | Fine to capture the tables into TR. Fine to clarify PRACH format, TBS scaling for msg2 and DL PSD. |
| Samsung |  | For Msg 2, it should be clarified whether or not Rel-15 TBS scaling was applied for each simulation result. |
| InterDigital | Y | We have provide some update on our results. |
| FL4 | Majority of responses are fine with capturing the above link budget evaluation results to TR 38.875. One response suggests the results can be captured in an Appendix of TR 38.875 by replacing company names with “source N”. Several responses comment to clarify evaluation assumption for msg2, PRACH and the assumed DL PSD.  For Msg2 results, some companies might have considered TBS scaling and some others have not. However, the assumption for TBS scaling is not available in the evaluation spreadsheet. The FL suggests the sourcing companies to clarify whether TBS scaling is used for Msg2 and also PRACH format.  Based on the responses, the FL makes the following proposal:  **[FL4] Proposal 3.3-1:**   * Capture the link budget evaluation results (Urban 4 GHz) in Table 3.3-1 to Table 3.3-3 to the Appendix of TR 38.875   + The tables will be further updated with potential updated coverage recovery evaluation results and a clarification of assumption for Msg2, PRACH and DL PSD. | |
| vivo |  | For MSG2, we use MCS#0 with no TBS scaling  For PRACH, only format B4 is captured according to the template. However, we believe for TDD, PRACH format 0 is possible for better coverage, therefore not proper to draw conclusion based on PRACH format B4 only.  For DL PSD, we assumed 33dBm/MHz |
| Qualcomm |  | We are fine with the FL updated proposal  For Msg2, no TBS scaling is used (3 RBs, MCS0, and TBS = 9 bytes) |
| Huawei, Hisilicon | N | Similar as Question 3.1-1.  We also suggest to clarify TBS scaling for msg2 and DL PSD.  For Msg2, TBS scaling is not enabled in our simulation.  For DL PSD, we assumed 33dBm/MHz |
| Intel | Y | We simulate Msg2 with scaling factor 1/4, PRACH format B4 and DL PSD 33dBm |
| Ericsson |  | Regarding DL PSD, our results are based on 24dBm/MHz. DL PSD assumption has very significant impacts on what observations to be drawn. So we suggest having separate tables for 24 dBm and 33 dBm. Separate observations may be drawn for the two different DL PSD settings.  Regarding TBS scaling for Msg2, we have provided results with and without TBS scaling. We suggest using results based on no TBS scaling as a baseline. TBS scaling can be considered as a coverage recovery technique for Msg2.  Regarding PRACH, our results are based on Format B4 (30 KHz SCS). |
| Samsung |  | No TBS scaling was used for Msg2. |
| Lenovo, Motorola Mobility |  | We updated table 3.3-1 and 3.3-2 and added our results.  No TBS scaling was used for Msg2. |
| ZTE |  | We are fine with the proposal.  For Msg.2, we use (3 RBs, MCS#0, TBS = 9 bytes) w/o TBS scaling. |
| InterDigital |  | For Msg2, we used 3 RBs, MCS0, 72 bits. |
| OPPO |  | For Msg2, we used 3 RBs, MCS0, without TBS scaling. |
| **FL5** | Based on the received responses, the FL’s updated suggestion is as following.  **[FL5] Updated Proposal 3.3-1:**   * Capture the link budget evaluation results (Urban 4 GHz) in Table 3.3-1 to Table 3.3-3 to the Appendix of TR 38.875   + The tables will be further updated with potential updated evaluation results (to catch potential typos) and a clarification of assumption for Msg2 and PRACH.   + MPL results to be included also. Up to editor to use the same or different tables. | |
| vivo | Y |  |

Based on the evaluation results in Table 3.3-1 to Table 3.3-3, the channels that potentially need coverage recovery in Urban scenario at 4 GHz and the summary of companies evaluation results for the margin to the coverage recovery target (i.e. the MIL of bottleneck channel for the reference NR UE) are summarized in Table 3.3-4, where the numbers in bracket is the number of samples.

**Table 3.3-4: Coverage recovery for RedCap UE in Urban scenario at 4 GHz (Option 3)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Channels | Mean | Median | Range | Representative value |
| 2Rx RedCap | PUSCH (12) | -3.0 | -3.0 | 1.4 | -2.9 |
| PDCCH CSS (12) | 8.9 | 7.5 | 24.1 | 8.7 |
| PDSCH (12) | 8.3 | 6.8 | 20.4 | 8.4 |
| Msg2 (11) | 5.4 | 3.3 | 29 | 4.9 |
| Msg4 (11) | 6.5 | 3.3 | 22.9 | 6.2 |
| 1Rx RedCap | PUSCH (12) | -3.0 | -3.0 | 1.2 | -3.0 |
| PDCCH CSS (12) | 4.5 | 2.8 | 23.7 | 4.5 |
| PDSCH (12) | 5.0 | 4.9 | 21.4 | 5.4 |
| Msg2 (11) | -0.1 | -0.5 | 32.2 | -0.9 |
| Msg4 (11) | 2.0 | -0.2 | 25.4 | 1.5 |

**Question 3.3-2: Can Table 3.3-4 be captured to TR 38.875? If not, any other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| FL |  | Table 3.3-4 has been updated by considering all the companies’ evaluation results. The representative value in the table is expected to be updated based on the agreement for the coverage recovery target in section 2, and the representative positive value indicates the LB of the concerned channel is better than the MIL of the bottleneck channel of the reference NR UE. |
| vivo |  | In the table, all channels except PUSCH have a range of 20+dB difference among companies, which seems too large. If possible, should we discuss a bit trying to identify the reason for such a large difference?  One thing worth noting is that companies are using power spectrum density of 24dBm/MHz find that downlink channels of MSG2 and MSG4 need to be enhanced, while there seems no coverage issue if 33dBm/MHz is assumed, hence the assumption for PSD should be mentioned in the proposals. |
| ZTE |  | Similar comment as to Question 3.1-2. |
| Nokia, NSB |  | Similar comment as to Question 3.1-2 |
| Futurewei |  | Same comment as 3.1-2. Since representative values have removed outliers its seems reasonable the values provided. |
| NTT DOCOMO |  | Similar comment as to Question 3.1-2.  And also we have the same view with vivo. We find large range for DL channels, so it may be better to identify the reason, and one of them might be the PSD difference. |
| Ericsson |  | We suggest clarifying (1) the meaning of the numbers in parentheses, and (2) how is the range computed (e.g., maximum-minimum).  Some evaluations are based on downlink power spectrum density 24 dBm/MHz, whereas some are based on 33 dBm/MHz. It might be better to have separate tables for the two different power spectrum density settings. |
| Intel |  | The table can be formed after proposal is section 2 is finalized. |
| Samsung |  | For DL channels, big gaps between companies are observed. Before capturing the results, some clarification and analysis on the big gap are necessary. |

Based on the results in Table 3.3-4, the following observations are proposed for discussion for the TP drafting for TR 38.875.

[FL notes: The observations will be updated based on the agreement for the coverage recovery target in section 2 and the update of Table 3.3-4]

**Moderator’s observation**

* P1: For RedCap UE in Urban scenario at 4 GHz, PUSCH is the channel that needs recovery and the amount of compensation is approximately 3dB.
* P2: For a RedCap UE with 2 Rx and 1Rx antenna at 4 GHz carrier frequency, four downlink channels, PDCCH CSS, Msg2, Msg4 and PDSCH do not reach the target coverage requirement and need for coverage recovery
  + A compensation of approximately 1.6 dB, 4.1 dB, 3.6 dB and 1.3 dB respectively, is observed for PDCCH CSS, Msg2, Msg4 and PDSCH for RedCap UE with 2Rx antenna
  + A compensation of approximately 4.8 dB, 7.4 dB, 4.0 dB and 5.6 dB respectively, is observed for PDCCH CSS, Msg2, Msg4 and PDSCH for RedCap UE with 1Rx antenna
* P3: Compared to the target coverage requirement, a coverage degradation of approximately 0.4 dB and 2.1 dB, respectively is observed for PDCCH USS and Msg3 by one source company for RedCap UE with 2 Rx
* P4: Compared to the target coverage requirement, a coverage degradation of approximately 4 dB, 2.2 dB and 2.1 dB, respectively is observed for PDCCH USS, PBCH and Msg3 by one source company for RedCap UE with 1 Rx

**Question 3.3-3: Can the above list (P1-P4) be used as a baseline text for TR 38.875? If not, what other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | N | Prefer to wait until proposal 1 is stable/agreed |
| Nokia, NSB |  | We prefer to wait until proposal 1 is agreed |
| Ericsson |  | Some evaluations are based on downlink power spectrum density 24 dBm/MHz, whereas some are based on 33 dBm/MHz. It might be better to have separate observations for the two different power spectrum density settings.  Furthermore, as our comments above, it will be good if the sourcing companies can clarify whether TBS scaling has been considered for Msg2. (This clarification may be needed for all the scenarios.)  P1: For PUSCH, it can be clarified the 3 dB coverage compensation is needed if the target data rate for RedCap UEs is the same as reference UE. We should add a note here to state that the 3 dB coverage compensation is not needed if the target data rate for RedCap UEs is reduced.  We can further mention that the 3 dB loss is resulting from the UE antenna efficiency loss assumed for the wearable use cases only. |
| Samsung |  | It can be mentioned that 3dB antenna loss is resulted from reduced antenna efficiency due to device size limitations for wearables. |
| Huawei, Hisilicon | N | Similar comment as to Question 3.1-2. |

**[FL5] Based on the received responses, the FL’s updated text proposal is as following.**

**(FL note: based on the outcome of Proposal 2-1, some numbers in the tables can be further updated, however, the conclusion is expected to be same)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| For Urban scenario at 4 GHz, the bottleneck channel for the reference NR UE and the corresponding maximum isotropic loss (MIL) value by the sourcing companies are shown in Table 9.1-7.  For RedCap UE with 1 Rx and 2 Rx, the MIL loss relative to the bottleneck channel of the reference NR UE is studied under different downlink power spectrum density assumptions. For DL PSD 33 dBm/MHz, the estimated coverage loss for 1 Rx and 2 Rx is summarized in Table 9.1-8 and Table 9.1-9, respectively. For DL PSD 24 dBm/MHz, the estimated coverage loss for 1 Rx and 2 Rx is summarized in Table 9.1-10 and Table 9.1-11, respectively. It is noted that the 3dB antenna efficiency loss is assumed in both DL and UL for the RedCap UE.  **Table 9.1-7: Bottleneck channel and MIL values for Reference NR UE in Urban 4 GHz**   |  |  |  | | --- | --- | --- | |  | Bottleneck Channel | MIL (dB) | | Samsung | PUSCH | 142.0 | | ZTE | PUSCH | 143.0 | | OPPO | PUSCH | 147.0 | | vivo | PUSCH | 139.3 | | Futurewei | PUSCH | 152.6 | | Nokia | PUSCH | 140.8 | | DCM | PUSCH | 146.8 | | Huawei | PUSCH | 140.0 | | SPRD | PUSCH | 145.4 | | Ericsson | Msg2 | 143.6 | | IDCC | PUSCH | 144.9 | | QC | PUSCH | 140.7 | | Intel | PUSCH | 140.0 | | Lenovo | PUSCH | 148.3 |   The representative values in the last row of Table 9.1-8 to Table 9.1-11 are derived by taking the mean value (in dB domain) from all the companies results and excluding the highest and the lowest values when the number of samples is more than 3. A negative value of the representative value for a channel of the RedCap UE indicates the coverage of the channel is worse than that of the bottleneck channel of the reference NR UE and coverage recovery is needed.  As can be seen in the last row for the representative value, all uplink channels except for PUSCH have better coverage than that of the bottleneck channel thus requiring no compensation. On average, a coverage degradation of approximately 3dB is observed for PUSCH.  It should be noted that the 3dB loss is resulted from the UE antenna efficiency loss assumed for the wearable use cases. Furthermore, the same target data rate of 1 Mbps for PUSCH is assumed for both RedCap UE and the reference NR UE (see evaluation methodology described in clause 6.3). A smaller coverage loss for PUSCH is expected if the target data rate for RedCap UE is reduced.  As seen from Table 9.1-8 and Table 9.1-9, for DL PSD 33 dBm/MHz, all the downlink channels are not coverage limited for both 1 Rx and 2 Rx RedCap UEs. The same conclusion is observed for DL PSD 24 dBm/MHz and 2 Rx RedCap UE. However, for DL PSD 24 dBm/MHz and 1 Rx RedCap UE, a coverage degradation of approximately 5.5 dB, 2.4 dB and 0.8 dB, respectively is observed for Msg2, Msg4 and PDCCH CSS as seen from Table 9.1-11.  **Table 9.1-8: Coverage loss (dB) for 2Rx RedCap UE in Urban 4 GHz with 33 dBm/MHz PSD (Option 3)**   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22 bits | PUSCH | Msg3 | PRACH | | Samsung | 18.0 | 22.0 | 14.8 | 13.7 | 14.7 |  | 13.3 | 9.5 | 6.5 | -3.0 | 5.0 |  | | vivo | 12.7 | 20.7 | 16.0 | 10.3 | 12.3 | 16.0 | 14.0 | 11.5 | 8.8 | -2.8 | 10.3 | 7.3 | | Nokia | 21.7 | 21.7 | 17.8 | 22.6 | 19.2 |  | 7.9 |  | 6.4 | -3.0 | 3.5 | 11.3 | | Huawei | 18.0 | 22.0 | 16.9 | 14.6 | 14.6 |  | 17.5 |  | 15.7 | -3.0 | 6.6 |  | | Representative value (dB) | **18.0** | **21.9** | **16.4** | **14.2** | **14.7** | **16.0** | **13.6** | **10.5** | **7.6** | **-3.0** | **5.8** | **9.3** |   **Table 9.1-9: Coverage loss (dB) for 1Rx RedCap UE in Urban 4 GHz with 33 dBm/MHz PSD (Option 3)**   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22 bits | PUSCH | Msg3 | PRACH | | Samsung | 14.5 | 18.5 | 10.1 | 8.5 | 11.1 |  | 13.3 | 9.5 | 6.5 | -3.0 | 5.0 |  | | ZTE | 9.6 | 17.6 | 11.4 | 5.6 | 7.5 | 13.4 | 14.0 | 11.5 | 8.8 | -2.8 | 10.3 | 7.3 | | OPPO | 17.7 | 17.7 | 14.0 | 18.8 | 15.7 |  | 7.9 |  | 6.4 | -3.0 | 3.5 | 11.3 | | CATT | 14.5 | 18.5 | 13.0 | 10.3 | 10.7 |  | 17.5 |  | 15.7 | -3.0 | 6.6 |  | | Representative value (dB) | **14.5** | **18.1** | **12.2** | **9.4** | **10.9** | **13.4** | **13.6** | **10.5** | **7.6** | **-3.0** | **5.8** | **9.3** |   **Table 9.1-10: Coverage loss (dB) for 2Rx RedCap UE in Urban 4 GHz with 24 dBm/MHz PSD (Option 3)**   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22 bits | PUSCH | Msg3 | PRACH | | OPPO | 5.1 | 9.1 | 7.5 | -0.7 | 3.0 |  | 4.9 | 5.0 | 4.9 | -3.0 | 4.7 |  | | Futurewei | -2.4 | -0.4 | -2.6 | -6.4 | -3.6 |  |  |  |  | -3.0 | -2.1 |  | | DCM | 4.1 | 8.1 | 4.0 | -2.8 | 0.2 |  | 11.5 | 15.1 |  | -3.0 | 4.9 |  | | SPRD | 4.3 | 8.5 | 6.3 | 3.3 | 3.3 | 6.3 | 9.8 | 7.8 | 9.6 | -3.0 | 5.1 | 7.1 | | Ericsson | -0.8 | 3.2 | -0.1 | -6.4 | -3.7 | 1.4 | 7.0 | 9.0 | 7.1 | -2.5 | 4.7 | 8.3 | | IDCC | 4.9 | 8.9 | 6.4 | 8.9 | 11.9 |  | 12.2 |  | 7.9 | -3.0 | 5.0 |  | | QC | 6.1 |  | 4.9 | 0.1 | 2.4 |  |  |  | 2.8 | -3.7 | 3.3 |  | | Intel\* | 10.4 | 11.5 | 6.5 | 11.4 | 8.6 | 13.3 | 18.5 | 17.3 | 14.7 | -2.3 | 11.2 | 13.3 | | Representative value (dB) | **4.0** | **7.6** | **4.7** | **0.4** | **2.3** | **6.3** | **10.1** | **10.6** | **7.4** | **-2.9** | **4.6** | **8.3** |   Note: A TBS scaling factor ¼ is assumed for Msg2 evaluation  **Table 9.1-11: Coverage loss (dB) for 1Rx RedCap UE in Urban 4 GHz with 24 dBm/MHz PSD (Option 3)**   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22 bits | PUSCH | Msg3 | PRACH | | ZTE | -4.5 | 6.0 | 8.6 | -1.3 | -1.1 |  | 16.6 | 14.9 | 12.3 | -3.0 | 10.3 |  | | OPPO | 1.2 | 5.2 | 4.9 | -6.2 | -0.8 |  | 4.9 | 5.0 | 4.9 | -3.0 | 4.7 |  | | Futurewei | -6.0 | -4.0 | -7.4 | -13.4 | -9.7 |  |  |  |  | -3.0 | -2.1 |  | | DCM | 0.8 | 4.8 | 0.0 | -8.5 | -3.9 |  | 11.5 | 15.1 |  | -3.0 | 4.9 |  | | SPRD | 1.3 | 5.5 | 3.3 | 0.3 | 0.3 | 3.3 | 9.8 | 7.8 | 9.6 | -3.0 | 5.1 | 7.1 | | Ericsson | -3.9 | 0.2 | -3.8 | -11.2 | -7.6 | -2.2 | 7.0 | 9.0 | 7.1 | -2.5 | 4.7 | 8.3 | | IDCC | 1.7 | 5.7 | 3.3 | 4.4 | 8.8 |  | 12.2 |  | 7.9 | -3.0 | 5.0 |  | | QC | 2.8 |  | 1.7 | -3.8 | -0.9 |  |  |  | 2.8 | -3.7 | 3.3 |  | | Lenovo | -2.0 |  | -2.6 | -8.1 | -2.9 |  | 11.7 | 6.9 | 5.7 | -3.0 | 2.9 |  | | Representative value (dB) | **-0.8** | **4.3** | **1.0** | **-5.5** | **-2.4** | **0.6** | **10.4** | **9.6** | **7.0** | **-3.0** | **4.4** | **7.7** | |

**[FL5] Question 3.3-1A:** **Can the above observations of the relative coverage loss be used as a baseline text for TR 38.875? If not, what aspects to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Panasonic | Y |  |
| vivo |  | It would be useful to make if clear   * + - 1. All companies except one company does not apply TBS scaling for MSG2       2. PRACH format B4 is simulated |
|  |  |  |

## FR2, Indoor with the carrier frequency of 28 GHz

Based on the latest available evaluation results in [RedCapCoverage-28GHz-v012-QC-Ericsson.xlsx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/drafts/8.6/EvaluationResults/RedCapCoverage/28GHz/RedCapCoverage-28GHz-v012-QC-Ericsson.xlsx), the link budget performance for both the reference UE and RedCap UE is summarized in Table 3.4-1 to Table 3.4-4 (Company please double check whether your results are correctly captured in these tables. We have found there are some mismatch between the spreadsheet and the contribution for some companies results).

In the link budget tables, the maximum isotropic loss (MIL) is used as the coverage evaluation metric and for each channel the margin to the target performance is also shown, where the target performance is a company specific value and derived based on the link budget of the bottleneck channel for the reference NR UE. The coverage limiting channel for RedCap UE, e.g. the link budget for the channel worse than that target performance, is highlighted with RED.

**Table 3.4-1: Link budget performance for the reference NR UE**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Indoor, 28GHz, 100MHz, 2Rx Ref NR UE** | | | | | | | | | | | | | | |
|  |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22bits | PUSCH | Msg3 | PRACH | Target /Option3 |
| Samsung | MIL (dB) | 146.5 | 146.5 | 141.3 | 145.1 | 142.5 |  | 157.8 | 153.8 | 150.9 | 133.3 | 149.4 |  | 133.3 |
| Margin (dB) | 13.2 | 13.2 | 8.0 | 11.8 | 9.2 |  | 24.5 | 20.5 | 17.6 | 0.0 | 16.1 |  |  |
| ZTE | MIL (dB) | 139.8 | 140.5 | 134.5 | 139.0 | 139.3 |  | 157.5 | 153.1 | 152.3 | 134.3 | 152.3 |  | 134.3 |
| Margin (dB) | 5.5 | 6.2 | 0.2 | 4.6 | 4.9 |  | 23.1 | 18.8 | 18.0 | 0.0 | 18.0 |  |  |
| OPPO | MIL (dB) | 145.9 | 145.9 | 142.9 | 144.6 | 144.2 |  | 160.0 | 159.7 | 160.0 | 141.9 | 160.2 |  | 141.9 |
| Margin (dB) | 4.0 | 4.0 | 1.0 | 2.8 | 2.3 |  | 18.2 | 17.8 | 18.1 | 0.0 | 18.4 |  |  |
| vivo | MIL (dB) | 135.5 | 140.5 | 136.0 | 133.7 | 135.1 | 139.8 | 153.9 | 152.3 | 149.0 | 131.4 | 142.8 | 142.6 | 131.4 |
| Margin (dB) | 4.1 | 9.1 | 4.6 | 2.3 | 3.8 | 8.4 | 22.6 | 20.9 | 17.6 | 0.0 | 11.4 | 11.2 |  |
| Nokia | MIL (dB) | 142.5 | 142.5 | 139.3 | 144.9 | 144.1 |  | 160.5 |  | 158.9 | 144.9 | 153.1 | 157.5 | 139.3 |
| Margin (dB) | 3.3 | 3.3 | 0.0 | 5.6 | 4.8 |  | 21.2 |  | 19.6 | 5.6 | 13.8 | 18.2 |  |
| DOCOMO | MIL (dB) | 148.6 | 148.6 | 143.0 | 143.3 | 142.0 |  | 158.6 | 164.0 |  | 147.3 | 160.3 |  | 142.0 |
| Margin (dB) | 6.6 | 6.6 | 1.0 | 1.3 | 0.0 |  | 16.6 | 22.0 |  | 5.4 | 18.3 |  |  |
| Ericsson | MIL (dB) | 132.1 | 133.1 | 128.4 | 128.2 | 128.0 | 134.3 | 150.5 | 150.9 | 148.4 | 138.7 | 146.3 | 149.1 | 128.0 |
| Margin (dB) | 4.1 | 5.1 | 0.4 | 0.2 | 0.0 | 6.3 | 22.5 | 22.9 | 20.4 | 10.7 | 18.3 | 21.1 |  |
| InterDigital | MIL (dB) | 147.3 | 147.3 | 142.67 | 143.32 | 142.47 |  | 166.3 |  | 160.7 | 143.4 | 159.35 |  | 142.47 |
| Margin (dB) | 4.8 | 4.8 | 0.2 | 0.85 | 0.0 |  | 23.83 |  | 18.2 | 0.9 | 16.88 |  |  |
| Qualcomm | MIL (dB) | 143.4 | 149.4 | 141.9 | 143.9 | 147.3 | 153.0 | 170.8 | 164.7 | 162.2 | 138.8 | 147.4 | 163.4 | 138.8 |
| Margin (dB) | 4.6 | 10.6 | 3.1 | 5.1 | 8.5 | 14.1 | 32.0 | 25.8 | 23.3 | 0.0 | 8.6 | 24.6 |  |
| Intel | MIL (dB) | 139.2 | 140.0 | 132.1 | 140.5 | 137.6 | 142.3 | 157.0 | 157.3 | 154.2 | 137.4 | 150.9 | 150.9 | 132.1 |
| Margin (dB) | 1.8 | 2.6 | 0 | 3.1 | 0.2 | 4.9 | 19.6 | 19.9 | 16.8 | 5.3 | 13.5 | 13.5 |  |

**Table 3.4-2: Link budget performance for the RedCap UE (100MHz BW, 1Rx)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Indoor, 28GHz, 100MHz, 1Rx RedCap UE** | | | | | | | | | | | | | | |
|  |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22bits | PUSCH | Msg3 | PRACH | Target /Option3 |
| Samsung | MIL (dB) | 142.3 | 142.4 | 136.4 | 139.5 | 137.2 |  | 157.5 | 153.9 | 150.4 | 133.3 | 149.4 |  | 133.3 |
| Margin (dB) | 9.0 | 9.1 | 3.1 | 6.2 | 3.9 |  | 24.2 | 20.6 | 17.1 | 0.0 | 16.1 |  |  |
| ZTE | MIL (dB) | 136.5 | 137.2 | 129.2 | 134.1 | 134.7 |  | 157.5 | 153.1 | 152.3 | 134.3 | 152.3 |  | 134.3 |
| Margin (dB) | 2.1 | 2.8 | -5.2 | -0.2 | 0.3 |  | 23.1 | 18.8 | 18.0 | 0.0 | 18.0 |  |  |
| OPPO | MIL (dB) | 141.0 | 141.0 | 138.8 | 140.1 | 139.4 |  | 160.0 | 159.7 | 160.0 | 141.9 | 160.2 |  | 141.9 |
| Margin (dB) | -0.9 | -0.9 | -3.1 | -1.7 | -2.5 |  | 18.2 | 17.8 | 18.1 | 0.0 | 18.4 |  |  |
| vivo | MIL (dB) | 131.8 | 136.8 | 130.8 | 127.3 | 130.5 | 134.3 | 153.9 | 152.3 | 149.0 | 131.4 | 142.8 | 142.6 | 131.4 |
| Margin (dB) | 0.4 | 5.4 | -0.6 | -4.0 | -0.8 | 2.9 | 22.6 | 20.9 | 17.6 | 0.0 | 11.4 | 11.2 |  |
| Nokia | MIL (dB) | 139.5 | 139.3 | 136.0 | 142.5 | 141.5 |  | 160.5 |  | 158.9 | 144.9 | 153.1 | 157.5 | 139.3 |
| Margin (dB) | 0.3 | 0.0 | -3.3 | 3.2 | 2.2 |  | 21.2 |  | 19.6 | 5.6 | 13.8 | 18.2 |  |
| DOCOMO | MIL (dB) | 144.9 | 144.9 | 138.4 | 137.1 | 137.0 |  | 158.6 | 164.0 |  | 147.3 | 160.3 |  | 142.0 |
| Margin (dB) | 2.9 | 2.9 | -3.5 | -4.8 | -5.0 |  | 16.6 | 22.0 |  | 5.4 | 18.3 |  |  |
| Ericsson | MIL (dB) | 128.2 | 129.2 | 124.4 | 124.8 | 123.5 | 130.6 | 150.5 | 150.5 | 148.1 | 138.7 | 146.3 | 149.1 | 128.0 |
| Margin (dB) | 0.2 | 1.2 | -3.6 | -3.2 | -4.5 | 2.6 | 22.5 | 22.6 | 20.1 | 10.7 | 18.3 | 21.1 |  |
| InterDigital | MIL (dB) | 143.5 | 143.5 | 138.56 | 138.0 | 137.90 |  | 166.3 |  | 160.7 | 143.4 | 159.35 |  | 142.47 |
| Margin (dB) | 1.0 | 1.0 | -3.9 | -4.47 | -4.57 |  | 23.9 |  | 18.2 | 0.9 | 16.88 |  |  |
| Qualcomm | MIL (dB) | 140.1 | 146.1 | 137.7 | 138.5 | 143.8 | 149.7 | 170.8 | 164.7 | 162.2 | 138.8 | 147.4 | 163.4 | 138.8 |
| Margin (dB) | 1.3 | 7.3 | -1.2 | -0.4 | 5.0 | 10.8 | 32.0 | 25.8 | 23.3 | 0.0 | 8.6 | 24.6 |  |
| Intel | MIL (dB) | 135.1 | 135.9 | 128.0 | 137.1 | 134.0 | 137.8 | 157.0 | 157.3 | 154.2 | 137.4 | 150.9 | 150.9 | 132.1 |
| Margin (dB) | 3.0 | 3.8 | -4.1 | 5.0 | 1.9 | 5.7 | 24.9 | 25.2 | 22.1 | 5.3 | 18.8 | 18.7 |  |

**Table 3.4-3: Link budget performance for the RedCap UE (50MHz BW, 2Rx)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Indoor, 28GHz, 50MHz, 2Rx RedCap UE** | | | | | | | | | | | | | | |
|  |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22bits | PUSCH | Msg3 | PRACH | Target /Option3 |
| Samsung | MIL (dB) | 146.0 | 145.9 | 137.0 | 145.1 | 142.5 |  | 157.5 | 153.9 | 150.4 | 133.3 | 149.4 |  | 133.3 |
| Margin (dB) | 12.7 | 12.6 | 3.7 | 11.8 | 9.2 |  | 24.2 | 20.6 | 17.1 | 0.0 | 16.1 |  |  |
| OPPO | MIL (dB) | 145.7 | 145.7 | 137.2 | 144.6 | 144.2 |  | 160.0 | 159.7 | 160.0 | 144.8 | 160.2 |  | 141.9 |
| Margin (dB) | 3.9 | 3.9 | -4.6 | 2.8 | 2.3 |  | 18.2 | 17.8 | 18.1 | 3.0 | 18.4 |  |  |
| DOCOMO | MIL (dB) | 144.8 | 144.8 | 137.4 | 143.3 | 142.0 |  | 158.6 | 164.0 |  | 145.9 | 160.3 |  | 142.0 |
| Margin (dB) | 2.9 | 2.9 | -4.6 | 1.3 | 0.0 |  | 16.6 | 22.0 |  | 4.0 | 18.3 |  |  |
| Ericsson | MIL (dB) | 130.2 | 131.2 | 124.8 | 129.2 | 128.0 | 134.3 | 150.5 | 150.5 | 148.1 | 143.6 | 146.3 | 149.1 | 128.0 |
| Margin (dB) | 2.2 | 3.2 | -3.2 | 1.2 | 0.0 | 6.3 | 22.5 | 22.6 | 20.1 | 15.7 | 18.3 | 21.1 |  |
| Qualcomm | MIL (dB) |  |  | 138.4 | 143.9 | 144.2 | 152.9 | 170.8 | 164.7 | 162.2 | 138.9 | 147.4 | 163.4 | 138.8 |
| Margin (dB) |  |  | -0.4 | 5.1 | 5.4 | 14.1 | 32.0 | 25.8 | 23.3 | 0.1 | 8.6 | 24.6 |  |

**Table 3.4-4: Link budget performance for the RedCap UE (50MHz BW, 1Rx)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Indoor, 28GHz, 50MHz, 1Rx RedCap UE** | | | | | | | | | | | | | | |
|  |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22bits | PUSCH | Msg3 | PRACH | Target /Option3 |
| Samsung | MIL (dB) | 141.6 | 141.6 | 130.9 | 139.5 | 137.2 |  | 157.5 | 153.9 | 150.4 | 133.3 | 149.4 |  | 133.3 |
| Margin (dB) | 8.3 | 8.3 | -2.4 | 6.2 | 3.9 |  | 24.2 | 20.6 | 17.1 | 0.0 | 16.1 |  |  |
| OPPO | MIL (dB) | 140.9 | 140.9 | 131.8 | 140.1 | 139.4 |  | 160.0 | 159.7 | 160.0 | 144.8 | 160.2 |  | 141.9 |
| Margin (dB) | -1.0 | -1.0 | -10.1 | -1.7 | -2.5 |  | 18.2 | 17.8 | 18.1 | 3.0 | 18.4 |  |  |
| DOCOMO | MIL (dB) | 140.3 | 140.3 | 131.3 | 137.1 | 137.0 |  | 158.6 | 164.0 |  | 145.9 | 160.3 |  | 142.0 |
| Margin (dB) | -1.7 | -1.7 | -10.7 | -4.8 | -5.0 |  | 16.6 | 22.0 |  | 4.0 | 18.3 |  |  |
| Ericsson | MIL (dB) | 126.1 | 127.1 | 120.1 | 124.8 | 123.5 | 130.6 | 150.5 | 150.5 | 148.1 | 143.6 | 146.3 | 149.1 | 128.0 |
| Margin (dB) | -1.9 | -0.9 | -7.9 | -3.2 | -4.5 | 2.6 | 22.5 | 22.6 | 20.1 | 15.7 | 18.3 | 21.1 |  |
| Qualcomm | MIL (dB) |  |  | 133.4 | 138.5 | 140.2 | 149.9 | 170.8 | 164.7 | 162.2 | 138.9 | 147.4 | 163.4 | 138.8 |
| Margin (dB) |  |  | -5.4 | -0.4 | 1.4 | 11.1 | 32.0 | 25.8 | 23.3 | 0.1 | 8.6 | 24.6 |  |

**Question 3.4-1: Can the link budget evaluation results in Table 3.4-1 to Table 3.4-4 be captured to TR 38.875? (Companies are invited to check the results and if any modification is needed, please also indicate here.)**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| ZTE | Y | Fine to capture the tables into the TR. |
| Qualcomm | Y |  |
| NTT DOCOMO | Y |  |
| Ericsson | Y |  |
| Intel | Y |  |
| Samsung |  | For Msg 2, it should be clarified whether or not Rel-15 TBS scaling was applied for each simulation result. |
| InterDigital | Y | We have provide some update on our results. |
| FL4 | Majority of responses are fine with capturing the above link budget evaluation results to TR 38.875. One responses comments to clarify evaluation assumption for msg2.  For Msg2 results, some companies might have considered TBS scaling and some others have not. However, the assumption for TBS scaling is not available in the evaluation spreadsheet. The FL suggests the sourcing companies to clarify whether TBS scaling is used for Msg2.  Based on the responses, the FL makes the following proposal:  **[FL4] Proposal 3.4-1:**   * Capture the link budget evaluation results (indoor 28 GHz) in Table 3.4-1 to Table 3.4-3 to the Appendix of TR 38.875   + The tables will be further updated with potential updated coverage recovery evaluation results and a clarification of assumption for Msg2 | |
| vivo |  | For MSG2, we used MCS#0 with no TBS scaling |
| Qualcomm |  | We are fine with the FL updated proposal  For Msg2, no TBS scaling is used (4 RBs, MCS0, and TBS = 96) |
| Huawei, Hisilicon | N | We prefer to wait until proposal 1 is agreed.  For Msg2, no TBS scaling is assumed in our simulation. |
| Intel | Y | We simulate Msg2 with scaling factor 1/4 |
| Ericsson |  | Regarding TBS scaling for Msg2, we have provided results with and without TBS scaling. We suggest using results based on no TBS scaling as a baseline. TBS scaling can be considered as a coverage recovery technique for Msg2. |
| Samsung |  | No TBS scaling was used for Msg2. |
| ZTE |  | We are fine with the proposal.  For Msg.2, we use (3 RBs, MCS#0, TBS = 9 bytes) w/o TBS scaling. |
| InterDigital | Y | For Msg2, we used 3 RBs, MCS0, 72 bits. |
| OPPO | Y | For Msg2, we used 3 RBs, MCS0, without TBS scaling. |
| FL5 | Based on the received responses, the FL’s updated suggestion is as following.  **[FL5] Updated Proposal 3.4-1:**   * Capture the link budget evaluation results (indoor 28 GHz) in Table 3.4-1 to Table 3.4-3 to the Appendix of TR 38.875   + The tables will be further updated with potential updated evaluation results (to catch potential typos) and a clarification of assumption for Msg2 and PRACH.   + MPL results to be included also. Up to editor to use the same or different tables | |
| vivo | Y |  |

Based on the evaluation results in Table 3.4-1 to Table 3.4-4, the channels that potentially need coverage recovery in indoor scenario at 28 GHz and the summary of companies evaluation results for the margin to the coverage recovery target (i.e. the MIL of bottleneck channel for the reference NR UE) are summarized in Table 3.4-5, where the numbers in bracket is the number of samples.

**Table 3.4-5: Coverage recovery for RedCap UE in indoor scenario at 28 GHz (Option 3)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Channels | Mean | Median | Range | Representative value |
| 1Rx RedCap 100MHz BW | PDSCH (10) | -3.1 | -3.4 | 12.4 | -3.1 |
| Msg2 (9) | -0.9 | -0.4 | 11.8 | -1.2 |
| Msg4 (9) | -0.5 | -0.8 | 10.0 | -0.7 |
| PDCCH CSS (5) | 1.4 | 0.7 | 11.3 | 0.9 |
| 2Rx RedCap 50MHz BW | PDSCH (5) | -1.8 | -3.2 | 8.3 | -2.7 |
| Msg2 (5) | 0.7 | 2.8 | 11.8 | 1.0 |
| Msg4 (5) | 0.4 | 2.3 | 10.4 | 0.5 |
| 1Rx RedCap 50MHz BW | PDSCH (5) | -7.3 | -7.9 | 8.2 | -7.8 |
| Msg2 (5) | -1.3 | -1.7 | 11.8 | -2.3 |
| Msg4 (5) | -1.3 | -2.5 | 8.8 | -1.9 |
| PDCCH CSS (4) | 0.9 | -1.4 | 10.2 | -1.4 |
| PDCCH USS (4) | 1.2 | -1.0 | 10.0 | -1.0 |

**Question 3.4-2: Can Table 3.4-5 be captured to TR 38.875? If not, any other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| FL |  | Table 3.4-5 has been updated by considering all the companies’ evaluation results. The representative value in the table is expected to be updated based on the agreement for the coverage recovery target in section 2, and the positive representative value indicates the LB of the concerned channel is better than the MIL of the bottleneck channel of the reference NR UE. |
| vivo |  | We have concern to use option 3 to determine the coverage issue and the amount of coverage compensation. From the simulation results, we found that with 20m or even 100m ISD target, there will be no coverage issue based on option1, however, based on option 3 there are many channels requiring compensation. We need to discuss what is the real target for FR2 indoor, do we really target >100m ISD for real deployment? |
| ZTE |  | Similar comment as to Question 3.1-2.  An editorial comment: It should be 1 Rx for RedCap 100MHz BW in Table 3.4-5. |
| Qualcomm | N | There is a typo in Table 3.4-5. 2Rx RedCap 100MHz BW shall be changed to 1Rx RedCap 100MHz BW.  Prefer to wait until proposal 1 is stable/agreed |
| Nokia, NSB |  | Similar comment as to Question 3.1-2 |
| Futurewei |  | A general remark seems only few companies (5) have provided results for the worst case redcap where it shown PDSCH that requires 7.8 dB compensation. It could be that due to having a smaller number of samples the compensation seems larger. Even with such existing techniques may be sufficient to for its recovery. |
| NTT DOCOMO |  | Similar comment as to Question 3.1-2. |
| Ericsson |  | We suggest clarifying (1) the meaning of the numbers in parentheses, and (2) how is the range computed (e.g., maximum-minimum).  “2Rx RedCap 100MHz BW” should be changed to “1Rx RedCap 100MHz BW” according to the caption of Table 3.4-2. |
| Samsung |  | For DL channels, big gaps between companies are observed. Before capturing the results, some clarification and analysis on the big gap are necessary. |

Based on the results in Table 3.4-5, the following observations are proposed for discussion for the TP drafting for TR 38.875.

[FL notes: The observations will be updated based on the agreement for the coverage recovery target in section 2 and the update of Table 3.4-5]

**Moderator’s observation**

* P1: For RedCap UE in indoor scenario at 28 GHz, all uplink channels can reach the target coverage requirement thus requiring no compensation
* P2: For RedCap UE with 100MHz BW and 1Rx antenna at 28 GHz carrier frequency, five downlink channels, PDSCH, Msg2, Msg4, PDCCH CSS and USS do not reach the target coverage requirement and need for coverage recovery
  + A compensation of approximately 3.8 dB, 2.4 dB, 3.2 dB, 1.6 dB and 1.2 dB respectively, is observed for PDSCH, Msg2, Msg4, PDCCH CSS and USS
* P3: For RedCap UE with 50MHz BW and 2Rx antenna at 28 GHz carrier frequency, three downlink channels, PDSCH, Msg2, and Msg4 do not reach the target coverage requirement and need for coverage recovery
  + A compensation of approximately 3.2 dB, 5.2 dB, and 4.7 dB respectively, is observed for PDSCH, Msg2 and Msg4
* P4: For RedCap UE with 50MHz BW and 1Rx antenna at 28 GHz carrier frequency, five downlink channels, PDSCH, Msg2, Msg4, PDCCH CSS and USS do not reach the target coverage requirement and need for coverage recovery
  + A compensation of approximately 7.3 dB, 3.1 dB, 4.0 dB, 1.5 dB and 1.2 dB respectively, is observed for PDSCH, Msg2, Msg4, PDCCH CSS and USS

**Question 3.4-3: Can the above list (P1-P4) be used as a baseline text for TR 38.875? If not, what other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | N | Prefer to wait until proposal 1 is stable/agreed |
| Ericsson |  | P1: ok  P2/P3/P4: need to clarify whether TBS scaling is considered. Perhaps, we can have separate observations for Msg2 with and without TBS scaling. (This clarification may be needed for all the scenarios.) |
| Samsung |  | We think PUSCH data rate at the cell edge in the simulation is too high for RedCap comparing with peak data rate. In practical network, a lower data rate might be used. In this case, the MIL of the bottleneck channel for reference UE gets close to PUCCH MIL. In this case, MIL values for DL control channels for the RedCap would become lower than the MIL of the bottleneck channels. Due to the reason, we think coverage compensation for DL channels (i.e. PDCCH) is needed. |
| Huawei, Hisilicon | N | We prefer to wait until proposal 1 is agreed. |

**[FL5] Based on the received responses, the FL’s updated text proposal is as following.**

**(FL note: based on the outcome of Proposal 2-1, some numbers in the tables can be further updated, and the observations for the channels to compensate may also be changed as discussed in section 2)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| For indoor scenario at 28 GHz, the bottleneck channel for the reference NR UE and the corresponding maximum isotropic loss (MIL) value by the sourcing companies are shown in Table 9.1-12.  For RedCap UE with 1 Rx and 2 Rx, the MIL loss relative to the bottleneck channel of the reference NR UE is studied under different maximum UE bandwidth assumptions. The estimated coverage loss for maximum 100 MHz BW and 1 Rx RedCap UE is summarized in Table 9.1-13. The estimated coverage loss for maximum 50 MHz BW and 1 Rx and 2 Rx is summarized in Table 9.1-14 and Table 9.1-15, respectively.  **Table 9.1-12: Bottleneck channel and MIL values for Reference NR UE in indoor 28 GHz**   |  |  |  | | --- | --- | --- | |  | Bottleneck channel | MIL | | Samsung | PUSCH | 133.3 | | ZTE | PUSCH | 134.3 | | OPPO | PUSCH | 141.9 | | vivo | PUSCH | 131.4 | | Nokia | PDSCH | 139.3 | | DCM | Msg4 | 142.0 | | Ericsson | Msg4 | 128.0 | | IDCC | Msg4 | 142.5 | | QC | PUSCH | 138.8 | | Intel | PDSCH | 132.1 |   The representative values in the last row of Table 9.1-13 to Table 9.1-15 are derived by taking the mean value (in dB domain) from all the companies results and excluding the highest and the lowest values when the number of samples is more than 3. A negative value of the representative value for a channel of the RedCap UE indicates the coverage of the channel is worse than that of the bottleneck channel of the reference NR UE and coverage recovery is needed.  As can be seen in the last row for the representative value, all uplink channels are not coverage limited for the RedCap UE with either better or similar coverage as the bottleneck channel of the reference NR UE. This is because at FR2 there is no assumption of reduced antenna efficiency for the RedCap UE and UL coverage is same as the reference NR UE.  For RedCap UE with maximum 100MHz BW and 1Rx, an averaged coverage degradation of approximately 3.0 dB, 1.6 dB and 1.2 dB respectively, is observed for PDSCH, Msg2 and Msg4. It should be noted that for Msg2 results, some companies might have considered TBS scaling and some others have not.  By comparing Table 9.1-7 with Table 9.1-9, it can be seen a smaller maximum UE bandwidth may request a larger compensation. For example, the averaged coverage degradation for PDSCH is increased to 7.8 dB for RedCap UE with maximum 50MHz BW and 1Rx.  For RedCap UE with maximum 50MHz BW and 2Rx, PDSCH needs to be compensated as seen from Table 9.1-14. A few sourcing companies also indicate coverage loss for Msg2 and Msg4, but on average no compensation is needed.  For RedCap UE with maximum 50MHz BW and 1Rx, a coverage degradation of 1.4 dB is observed for PDCCH CSS and coverage recovery needs to be considered.  **Table 9.1-13: Coverage loss (dB) for RedCap UE (1Rx, 100MHz BW) in indoor scenario at 28 GHz (Option 3)**   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22 bits | PUSCH | Msg3 | PRACH | | Samsung | 9.0 | 9.1 | 3.1 | 6.2 | 3.9 |  | 24.2 | 20.6 | 17.1 | 0.0 | 16.1 |  | | ZTE | 2.1 | 2.8 | -5.2 | -0.2 | 0.3 |  | 23.1 | 18.8 | 18.0 | 0.0 | 18.0 |  | | OPPO | -0.9 | -0.9 | -3.1 | -1.7 | -2.5 |  | 18.2 | 17.8 | 18.1 | 0.0 | 18.4 |  | | vivo | 0.4 | 5.4 | -0.6 | -4.0 | -0.8 | 2.9 | 22.6 | 20.9 | 17.6 | 0.0 | 11.4 | 11.2 | | Nokia | 0.3 | 0.0 | -3.3 | 3.2 | 2.2 |  | 21.2 |  | 19.6 | 5.6 | 13.8 | 18.2 | | DCM | 2.9 | 2.9 | -3.5 | -4.8 | -5.0 |  | 16.6 | 22.0 |  | 5.4 | 18.3 |  | | Ericsson | 0.2 | 1.2 | -3.6 | -5.6 | -4.5 | 2.6 | 22.5 | 22.6 | 20.1 | 10.7 | 18.3 | 21.1 | | IDCC | 1.0 | 1.0 | -3.9 | -4.5 | -4.6 |  | 23.8 |  | 18.2 | 0.9 | 16.9 |  | | QC | 1.3 | 7.3 | -1.2 | -0.4 | 5.0 | 10.8 | 32.0 | 25.8 | 23.3 | 0.0 | 8.6 | 24.6 | | Intel\* | 3.0 | 3.8 | -4.1 | 5.0 | 1.9 | 5.7 | 24.9 | 25.2 | 22.1 | 5.3 | 18.8 | 18.7 | | Representative value (dB) | **1.4** | **3.0** | **-2.9** | **-0.9** | **-0.5** | **4.3** | **22.6** | **21.7** | **19.1** | **2.2** | **16.4** | **19.3** |   Note: A TBS scaling factor ¼ is assumed for Msg2 evaluation  **Table 9.1-14: Coverage loss (dB) for RedCap UE (2Rx, 50MHz BW) in indoor scenario at 28 GHz (Option 3)**   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22 bits | PUSCH | Msg3 | PRACH | | Samsung | 12.7 | 12.6 | 3.7 | 11.8 | 9.2 |  | 24.2 | 20.6 | 17.1 | 0.0 | 16.1 |  | | OPPO | 3.9 | 3.9 | -4.6 | 2.8 | 2.3 |  | 18.2 | 17.8 | 18.1 | 3.0 | 18.4 |  | | DCM | 2.9 | 2.9 | -4.6 | 1.3 | 0.0 |  | 16.6 | 22.0 |  | 4.0 | 18.3 |  | | Ericsson | 2.2 | 3.2 | -3.2 | 1.2 | 0.0 | 6.3 | 22.5 | 22.6 | 20.1 | 15.7 | 18.3 | 21.1 | | QC |  |  | -0.4 | 5.1 | 5.4 | 14.1 | 32.0 | 25.8 | 23.3 | 0.1 | 8.6 | 24.6 | | Representative value (dB) | **3.4** | **3.5** | **-2.7** | **3.1** | **2.6** | **10.2** | **21.6** | **21.7** | **19.1** | **2.3** | **17.6** | **22.8** |   **Table 9.1-15: Coverage loss (dB) for RedCap UE (1Rx, 50MHz BW) in indoor scenario at 28 GHz (Option 3)**   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22 bits | PUSCH | Msg3 | PRACH | | Samsung | 8.3 | 8.3 | -2.4 | 6.2 | 3.9 |  | 24.2 | 20.6 | 17.1 | 0.0 | 16.1 |  | | OPPO | -1.0 | -1.0 | -10.1 | -1.7 | -2.5 |  | 18.2 | 17.8 | 18.1 | 3.0 | 18.4 |  | | DCM | -1.7 | -1.7 | -10.7 | -4.8 | -5.0 |  | 16.6 | 22.0 |  | 4.0 | 18.3 |  | | Ericsson | -1.9 | -0.9 | -7.9 | -3.2 | -4.5 | 2.6 | 22.5 | 22.6 | 20.1 | 15.7 | 18.3 | 21.1 | | QC |  |  | -5.4 | -0.4 | 1.4 | 11.1 | 32.0 | 25.8 | 23.3 | 0.1 | 8.6 | 24.6 | | Representative value (dB) | **-1.4** | **-1.0** | **-7.8** | **-1.8** | **-1.9** | **6.8** | **21.6** | **21.7** | **19.1** | **2.3** | **17.6** | **22.8** | |

**[FL5] Question 3.4-1A:** **Can the above observations of the relative coverage loss be used as a baseline text for TR 38.875? If not, what aspects to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Panasonic | Y |  |
| vivo | N | As we commented in **[FL5] Question 2-1,** we have concern to draw observation solely based on Option 3 for FR2 indoor scenario. In particular, PDSCH and MSG4 coverage compensation is only needed in this scenario if Option 3 is solely considered. However, it would be a false issue if even we consider up to 100m ISD.  We would like to hear companies’ feedback about overcompensation issue. |
|  |  |  |

## Conclusion

**[FL5] Based on the observations in previous sections, the following recommendation on coverage recovery can be considered.**

|  |
| --- |
| * Dependent on frequency bands, the channels to compensate and the amount of coverage recovery could be different. * For FR1, we may need coverage recovery for PUSCH and Msg3 when considering potential reduced antenna efficiency due to device size limitations. The amount of coverage recovery is up to 3 dB. * For carrier frequency of 4 GHz with DL PSD 24 dBm/MHz, considering RedCap UE with 1 Rx and reduced antenna efficiency, we need coverage recovery also for Msg2, Msg4 and PDCCH CSS. A small or moderate compensation can be considered, i.e. 1-2 dB for Msg4 and PDCCH CSS and 5-6 dB for Msg2. * For FR2, UL coverage is same as the reference NR UE due to no assumption of reduced antenna efficiency for the RedCap UE. Coverage recovery is needed for Msg2, Msg4 and PDSCH due to performance loss from reducing the number of receiver branches to 1 and the amount of coverage recovery is 2-3 dB. |

**[FL5] Question 3.5-1:** **Should TR 38.875 make recommendations on the channels to compensate and the amount of coverage recovery? If yes, companies are invited to provide views for the above text proposals.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Panasonic | Y |  |
| vivo | N | As we commented before, we have concern about drawing conclusion for FR2 indoor solely based on Option 3 without considering the actual deployment need. |
|  |  |  |

# Capacity impact

Based on the latest available evaluation results in [RedCapCapacity-v012-MTK2-vivo2](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/drafts/8.6/EvaluationResults/RedCapCapacity/RedCapCapacity-v012-MTK2-vivo2.xlsx), the SLS evaluation of complexity reduction to network capacity are summarized in Table 4-1 to Table 4-24 (Company please double check whether your results are correctly captured in these tables. The original format in the spreadsheet is not friendly for comparing results, so I use a different format in this summary).

**Table 4-1: Downlink capacity evaluation for burst traffic (2.6GHz, low loading, 2Rx RedCap UE)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **2.6GHz, DL, 2Rx RedCap, low loading (RU<30%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson (note 1) | eMBB UE | 634.00 | 636.00 | 630.00 | \ | 317.00 | 315.00 | 313.00 | \ | 6.30 |  |  | \ |
| RedCap UE | \ | 86.00 | 85.00 | 83.00 | \ | 38.00 | 37.00 | 37.00 | \ |  |  | 4.10 |
| All UEs | 634.00 | 634.00 | 625.00 | 83.00 | 317.00 | 306.00 | 272.00 | 37.00 | 6.30 | 6.30 | 6.20 | 4.10 |
| Huawei (note 2) | eMBB UE | 86.96 | 58.82 | 39.22 | \ | 33.33 | 21.98 | 16.95 | \ | 5.76 | 5.68 | 4.87 | \ |
| RedCap UE | \ | 29.41 | 30.77 | 46.51 | \ | 10.93 | 9.09 | 14.81 | \ | 3.20 | 3.17 | 2.87 |
| All UEs | 86.96 | 50.41 | 35.72 | 46.51 | 33.33 | 19.22 | 14.02 | 14.81 | 5.76 | 5.44 | 3.65 | 2.87 |
| vivo  (note 3) | eMBB UE | 464.86 | 470.23 | 465.56 |  | 164.03 | 162.74 | 164.62 |  | 5.47 | 5.49 | 5.49 |  |
| RedCap UE | \ | 39.00 | 38.13 |  | \ | 16.03 | 15.34 |  | \ | 2.64 | 2.61 |  |
| All UEs | 464.86 | 456.49 | 431.54 |  | 164.03 | 98.10 | 37.44 |  | 5.47 | 5.45 | 5.37 |  |
| MTK  (note 4) | eMBB UE | 365.00 |  |  | \ | 176.00 |  |  | \ | 6.15 |  |  | \ |
| RedCap UE | \ |  |  | 30.00 | \ |  |  | 1.00 | \ |  |  | 3.47 |
| All UEs | 365.00 |  |  | 30.00 | 176.00 |  |  | 1.00 | 6.15 |  |  | 3.47 |
| Qualcomm (note 5) | eMBB UE | 168.12 | 176.74 | 204.66 | \ | 57.05 | 67.20 | 87.43 | \ | 8.98 | 9.22 | 9.70 | \ |
| RedCap UE | \ | 46.72 | 43.41 | 71.02 | \ | 4.04 | 2.14 | 5.68 | \ | 6.75 | 5.19 | 8.47 |
| All UEs | 168.12 | 134.86 | 84.85 | 71.02 | 57.05 | 14.64 | 5.31 | 5.68 | 8.98 | 8.60 | 7.44 | 8.47 |
| Nokia  (note 6) | eMBB UE | 402.48 | 447.58 | 569.93 | \ | 188.97 | 219.51 | 311.09 | \ | 4.79 | 5.31 | 6.43 | \ |
| RedCap UE | \ | 21.52 | 52.06 | 52.05 | \ | 3.94 | 19.81 | 18.97 | \ | 1.32 | 2.40 | 2.40 |
| All UEs | 402.48 | 377.15 | 133.94 | 52.05 | 188.97 | 9.80 | 26.79 | 18.97 | 4.79 | 4.31 | 4.42 | 2.40 |
| Note 1: FTP mode 3 (0.5MB payload every 200ms) and max 256 QAM for eMBB UE. IM model (0.1 MB payload every 2s) and max 64QAM for RedCap UE. Max scheduled BW is 100 MHz and 20 MHz for eMBB UEs and RedCap UEs, respectively.  Note 2: FTP model 3 for both eMBB and RedCap UEs. Packet size is 0.125 Mbytes and mean inter-arrival time is 200 ms. Max 20MHz scheduled bandwidth assumed for both eMBB and RedCap UEs. Total number of UEs per cell is 4 same for all the RedCap UE ratios.  Note 3: IM traffic (0.1 MB payload every 2s), 20MHz BW and max 64QAM for RedCap UE. FTP model 3 (0.5MB payload every 200ms), 100MHz BW and max 256QAM for eMBB UE.  Note 4: FTP model 3 for both eMBB and RedCap UEs. Packet size is 0.5 Mbytes and mean inter-arrival time 200 ms  Note 5: FTP model 3 for eMBB UE and IM model for RedCap UE. The mean inter-arrival time for FTP model 3 is changed with different RedCap UE ratios for achieving a target RU.  Note 6: FTP model 3 for both eMBB and RedCap UEs. Total number of UEs per cell is 10 | | | | | | | | | | | | | |

**Table 4-2: Downlink capacity evaluation for burst traffic (2.6GHz, low loading, 1Rx RedCap UE)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **2.6GHz, DL, 1Rx RedCap, low loading (RU<30%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson | eMBB UE | 634.00 | 634.00 | 632.00 | \ | 317.00 | 315.00 | 314.00 | \ | 6.30 |  |  | \ |
| RedCap UE | \ | 63.00 | 63.00 | 63.00 | \ | 30.00 | 29.00 | 27.00 | \ |  |  | 2.90 |
| All UEs | 634.00 | 632.00 | 627.00 | 63.00 | 317.00 | 302.00 | 268.00 | 27.00 | 6.30 | 5.90 | 6.10 | 2.90 |
| Huawei | eMBB UE | 86.96 | 42.55 | 25.98 | \ | 33.33 | 15.38 | 8.89 | \ | 5.76 | 5.22 | 4.99 | \ |
| RedCap UE | \ | 19.05 | 21.05 | 25.32 | \ | 7.41 | 7.38 | 7.25 | \ | 2.34 | 2.19 | 2.10 |
| All UEs | 86.96 | 36.00 | 23.31 | 25.32 | 33.33 | 13.59 | 8.24 | 7.25 | 5.76 | 4.25 | 2.98 | 2.10 |
| vivo | eMBB UE | 488.09 | 471.06 | 471.38 |  | 177.71 | 162.54 | 165.98 |  | 5.75 | 5.49 | 5.53 |  |
| RedCap UE | \ | 36.39 | 35.20 |  | \ | 13.54 | 13.80 |  | \ | 2.35 | 2.38 |  |
| All UEs | 488.09 | 456.73 | 436.73 |  | 177.71 | 95.10 | 34.73 |  | 5.75 | 5.43 | 5.39 |  |
| MTK | eMBB UE | 365.00 |  |  | \ | 176.00 |  |  | \ | 6.15 |  |  | \ |
| RedCap UE | \ |  |  | 16.00 | \ |  |  | 2.00 | \ |  |  | 2.50 |
| All UEs | 365.00 |  |  | 16.00 | 176.00 |  |  | 2.00 | 6.15 |  |  | 2.50 |
| Qualcomm | eMBB UE | 168.12 | 176.95 | 212.95 | \ | 57.05 | 71.71 | 98.93 | \ | 8.98 | 8.95 | 9.63 | \ |
| RedCap UE | \ | 36.20 | 31.15 | 41.79 | \ | 1.13 | 0.92 | 2.28 | \ | 3.95 | 3.13 | 3.98 |
| All UEs | 168.12 | 132.78 | 61.29 | 41.79 | 57.05 | 10.61 | 2.48 | 2.28 | 8.98 | 7.70 | 6.38 | 3.98 |
| Nokia | eMBB UE | 402.48 | 447.58 | 569.93 | \ | 188.97 | 219.51 | 311.09 | \ | 4.79 | 5.31 | 6.43 | \ |
| RedCap UE | \ | 18.93 | 41.51 | 41.51 | \ | 3.88 | 14.47 | 14.73 | \ | 1.19 | 1.72 | 1.72 |
| All UEs | 402.48 | 377.17 | 133.97 | 41.51 | 188.97 | 7.72 | 18.24 | 14.73 | 4.79 | 4.28 | 4.08 | 1.72 |

**Table 4-3: Downlink capacity evaluation for burst traffic (2.6GHz, medium loading, 2Rx RedCap UE)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **2.6GHz, DL, 2Rx RedCap, medium loading (30%<RU<50%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson  (note 1) | eMBB UE | 512.00 | 518.00 | 521.00 | \ | 227.00 | 233.00 | 237.00 | \ | 6.00 |  |  | \ |
| RedCap UE | \ | 67.00 | 67.00 | 64.00 | \ | 29.00 | 28.00 | 27.00 | \ |  |  | 3.80 |
| All UEs | 512.00 | 516.00 | 515.00 | 64.00 | 227.00 | 224.00 | 206.00 | 27.00 | 6.00 | 5.90 | 5.80 | 3.80 |
| Huawei  (note 2) | eMBB UE | 64.52 | 41.67 | 28.57 | \ | 20.10 | 12.20 | 8.70 | \ | 5.33 | 5.45 | 4.90 | \ |
| RedCap UE | \ | 22.22 | 19.23 | 28.57 | \ | 6.92 | 4.38 | 7.25 | \ | 3.85 | 3.83 | 3.58 |
| All UEs | 64.52 | 38.61 | 26.23 | 28.57 | 20.10 | 10.88 | 4.66 | 7.25 | 5.33 | 4.64 | 4.34 | 3.58 |
| Vivo  (note 3) | eMBB UE | 388.54 | 392.09 | 397.28 |  | 97.68 | 94.44 | 97.61 |  | 5.13 | 5.09 | 5.14 |  |
| RedCap UE | \ | 27.10 | 27.56 |  | \ | 7.82 | 7.74 |  | \ | 2.53 | 2.61 |  |
| All UEs | 388.54 | 378.54 | 356.91 |  | 97.68 | 59.23 | 25.42 |  | 5.13 | 5.06 | 5.04 |  |
| MTK  (note 4) | eMBB UE | 258.00 |  |  | \ | 90.00 |  |  | \ | 5.80 |  |  | \ |
| RedCap UE | \ |  |  | 18.00 | \ |  |  | 0.50 | \ |  |  | 2.40 |
| All UEs | 258.00 |  |  | 18.00 | 90.00 |  |  | 0.50 | 5.80 |  |  | 2.40 |
| Qualcomm  (note 5) | eMBB UE | 139.30 | 152.74 | 187.06 | \ | 51.80 | 61.85 | 84.05 | \ | 7.99 | 8.26 | 9.09 | \ |
| RedCap UE | \ | 43.72 | 37.23 | 71.02 | \ | 1.75 | 1.71 | 5.68 | \ | 5.50 | 4.82 | 8.47 |
| All UEs | 139.30 | 117.80 | 80.72 | 71.02 | 51.80 | 11.51 | 4.08 | 5.68 | 7.99 | 7.57 | 6.95 | 8.47 |
| Nokia  (note 6) | eMBB UE | 300.05 | 407.42 | 413.37 | \ | 105.19 | 190.68 | 193.98 | \ | 3.68 | 4.79 | 4.79 | \ |
| RedCap UE | \ | 18.92 | 18.15 | 22.28 | \ | 2.73 | 2.34 | 3.83 | \ | 1.27 | 1.27 | 1.32 |
| All UEs | 300.05 | 330.63 | 106.32 | 22.28 | 105.19 | 7.50 | 3.77 | 3.83 | 3.68 | 3.91 | 3.03 | 1.32 |
| Note 1: FTP mode 3 (0.5MB payload every 200ms) and max 256QAM for eMBB UE. IM model (0.1 MB payload every 2s) and max 64QAM for RedCap UE. Max scheduled BW is 100 MHz and 20 MHz for eMBB UEs and RedCap UEs, respectively.  Note 2: FTP model 3 for both eMBB and RedCap UEs. Packet size is 0.125 Mbytes and mean inter-arrival time is 200 ms. Max 20MHz scheduled bandwidth assumed for both eMBB and RedCap UEs. Total number of UEs per cell is 8 same for all the RedCap UE ratios.  Note 3: IM traffic (0.1 MB payload every 2s), 20MHz BW and max 64QAM for RedCap UE. FTP model 3 (0.5MB payload every 200ms), 100MHz BW and max 256QAM for eMBB UE.  Note 4: FTP model 3 for both eMBB and RedCap UEs. Packet size is 0.5 Mbytes and mean inter-arrival time 200 ms  Note 5: FTP model 3 for eMBB UE and IM model for RedCap UE. The mean inter-arrival time for FTP model 3 is changed with different RedCap UE ratios for achieving a target RU.  Note 6: FTP model 3 for both eMBB and RedCap UEs. Total number of UEs per cell is 10 | | | | | | | | | | | | | |

**Table 4-4: Downlink capacity evaluation for burst traffic (2.6GHz, medium loading, 1Rx RedCap UE)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **2.6GHz, DL, 1Rx RedCap, medium loading (30%<RU<50%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson | eMBB UE | 511.00 | 515.00 | 511.00 | \ | 227.00 | 236.00 | 231.00 | \ | 6.00 |  |  | \ |
| RedCap UE | \ | 52.00 | 52.00 | 51.00 | \ | 20.00 | 20.00 | 19.00 | \ |  |  | 2.80 |
| All UEs | 511.00 | 512.00 | 504.00 | 51.00 | 227.00 | 224.00 | 200.00 | 19.00 | 6.00 | 5.90 | 5.60 | 2.80 |
| Huawei | eMBB UE | 64.52 | 27.78 | 18.18 | \ | 20.10 | 7.25 | 4.52 | \ | 5.33 | 5.25 | 5.23 | \ |
| RedCap UE | \ | 14.49 | 13.70 | 16.13 | \ | 4.03 | 2.44 | 2.73 | \ | 2.41 | 2.72 | 2.96 |
| All UEs | 64.52 | 26.07 | 16.86 | 16.13 | 20.10 | 6.55 | 3.67 | 2.73 | 5.33 | 3.75 | 3.32 | 2.96 |
| vivo | eMBB UE | 396.74 | 392.38 | 387.63 |  | 102.39 | 97.20 | 95.89 |  | 5.22 | 5.13 | 5.09 |  |
| RedCap UE | \ | 25.54 | 24.37 |  | \ | 7.73 | 7.24 |  | \ | 2.36 | 2.31 |  |
| All UEs | 396.74 | 379.11 | 347.19 |  | 102.39 | 59.83 | 22.79 |  | 5.22 | 5.09 | 4.98 |  |
| MTK | eMBB UE | 258.00 |  |  | \ | 90.00 |  |  | \ | 5.80 |  |  | \ |
| RedCap UE | \ |  |  | 2.00 | \ |  |  | 0.30 | \ |  |  | 2.00 |
| All UEs | 258.00 |  |  | 2.00 | 90.00 |  |  | 0.30 | 5.80 |  |  | 2.00 |
| Qualcomm | eMBB UE | 139.30 | 154.16 | 186.99 | \ | 51.80 | 61.23 | 90.52 | \ | 7.99 | 8.07 | 8.86 | \ |
| RedCap UE | \ | 31.78 | 27.43 | 41.79 | \ | 0.79 | 0.78 | 2.28 | \ | 3.24 | 2.96 | 3.98 |
| All UEs | 139.30 | 112.21 | 61.16 | 41.79 | 51.80 | 8.90 | 1.80 | 2.28 | 7.99 | 6.86 | 5.91 | 3.98 |
| Nokia | eMBB UE | 300.05 | 407.42 | 413.37 | \ | 105.19 | 190.68 | 193.98 | \ | 3.68 | 4.79 | 4.79 | \ |
| RedCap UE | \ | 17.18 | 16.19 | 26.67 | \ | 2.70 | 2.55 | 5.84 | \ | 1.20 | 1.20 | 1.29 |
| All UEs | 300.05 | 330.64 | 77.96 | 26.67 | 105.19 | 6.01 | 3.60 | 5.84 | 3.68 | 3.89 | 2.99 | 1.29 |

**Table 4-5: Uplink capacity evaluation for burst traffic (2.6GHz, low loading)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **2.6GHz, UL, low loading (RU<30%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson | eMBB UE | 47.000 | 47.000 | 47.000 | \ | 3.000 | 3.000 | 3.000 | \ | 0.40 |  |  | \ |
| RedCap UE | \ | 12.000 | 12.000 | 11.000 | \ | 2.700 | 2.700 | 2.400 | \ |  |  | 0.40 |
| All UEs | 47.000 | 46.000 | 46.000 | 11.000 | 3.000 | 3.000 | 3.000 | 2.400 | 0.40 | 0.40 | 0.40 | 0.40 |
| Huawei | eMBB UE | 8.420 |  | 3.430 | \ | 0.220 |  | 0.220 | \ | 1.66 |  | 1.65 | \ |
| RedCap UE | \ |  | 1.940 | 4.300 | \ |  | 0.210 | 0.230 | \ |  | 0.84 | 0.82 |
| All UEs | 8.420 |  | 2.880 | 4.300 | 0.220 |  | 0.220 | 0.230 | 1.66 |  | 1.16 | 0.82 |
| vivo | eMBB UE | 21.400 | 22.811 | 23.444 |  | 0.063 | 0.061 | 0.059 |  | 1.01 | 1.01 | 1.01 |  |
| RedCap UE | \ | 0.556 | 0.473 |  | \ | 0.070 | 0.004 |  | \ | 0.24 | 0.24 |  |
| All UEs | 21.400 | 8.695 | 4.489 |  | 0.063 | 0.062 | 0.058 |  | 1.01 | 0.96 | 0.88 |  |
| MTK | eMBB UE | 82.000 |  |  | \ | 14.000 |  |  | \ | 0.60 |  |  | \ |
| RedCap UE | \ |  |  | 7.000 | \ |  |  | 4.000 | \ |  |  | 0.40 |
| All UEs | 82.000 |  |  | 7.000 | 14.000 |  |  | 4.000 | 0.60 |  |  | 0.40 |
| Nokia | eMBB UE | 45.974 | 46.240 | 46.967 | \ | 18.319 | 18.518 | 17.608 | \ | 0.52 | 0.52 | 0.52 | \ |
| RedCap UE | \ | 7.427 | 7.435 | 7.435 | \ | 4.991 | 5.008 | 5.000 | \ | 0.40 | 0.40 | 0.40 |
| All UEs | 45.974 | 36.354 | 11.072 | 7.435 | 18.319 | 6.946 | 6.025 | 5.000 | 0.52 | 0.49 | 0.46 | 0.40 |

**Table 4-6: Uplink capacity evaluation for burst traffic (2.6GHz, medium loading)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **2.6GHz, UL, medium loading (30%<RU<50%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson | eMBB UE | 37.000 | 37.000 | 37.000 | \ | 1.700 | 1.700 | 1.600 | \ | 0.40 |  |  | \ |
| RedCap UE | \ | 11.000 | 11.000 | 11.000 | \ | 1.500 | 1.600 | 1.400 | \ |  |  | 0.50 |
| All UEs | 37.000 | 37.000 | 36.000 | 11.000 | 1.700 | 1.700 | 1.600 | 1.400 | 0.40 | 0.40 | 0.40 | 0.50 |
| Huawei | eMBB UE | 7.340 | 5.230 | 3.400 | \ | 0.220 | 0.220 | 0.230 | \ | 2.04 | 2.20 | 2.22 | \ |
| RedCap UE | \ | 2.470 | 2.010 | 3.600 | \ | 0.190 | 0.220 | 0.240 | \ | 0.73 | 0.97 | 1.34 |
| All UEs | 7.340 | 4.410 | 2.900 | 3.600 | 0.220 | 0.200 | 0.220 | 0.240 | 2.04 | 1.82 | 1.59 | 1.34 |
| vivo | eMBB UE | 19.929 | 19.877 | 18.060 |  | 0.065 | 0.064 | 0.061 |  | 1.01 | 1.01 | 1.01 |  |
| RedCap UE | \ | 0.328 | 0.398 |  | \ | 0.034 | 0.032 |  | \ | 0.25 | 0.25 |  |
| All UEs | 19.929 | 14.120 | 2.791 |  | 0.065 | 0.062 | 0.056 |  | 1.01 | 0.96 | 0.90 |  |
| MTK | eMBB UE | 63.000 |  |  | \ | 9.000 |  |  | \ | 0.56 |  |  | \ |
| RedCap UE | \ |  |  | 7.000 | \ |  |  | 2.500 | \ |  |  | 0.40 |
| All UEs | 63.000 |  |  | 7.000 | 9.000 |  |  | 2.500 | 0.56 |  |  | 0.40 |
| Nokia | eMBB UE | 35.769 | 35.710 | 36.162 | \ | 11.898 | 11.898 | 11.163 | \ | 0.49 | 0.49 | 0.49 | \ |
| RedCap UE | \ | 6.968 | 7.079 | 7.150 | \ | 3.514 | 3.289 | 3.313 | \ | 0.39 | 0.39 | 0.39 |
| All UEs | 35.769 | 29.122 | 7.783 | 7.150 | 11.898 | 5.171 | 4.040 | 3.313 | 0.49 | 0.47 | 0.44 | 0.39 |

**Table 4-7: Downlink capacity evaluation for burst traffic (4GHz, low loading, 2Rx RedCap UE)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **4 GHz, DL, 2Rx RedCap, low loading (RU<30%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson | eMBB UE | 506.00 | 507.00 | 504.00 | \ | 152.00 | 153.00 | 153.00 | \ | 3.80 |  |  | \ |
| RedCap UE | \ | 64.00 | 63.00 | 64.00 | \ | 16.00 | 15.00 | 15.00 | \ |  |  | 2.30 |
| All UEs | 506.00 | 506.00 | 497.00 | 64.00 | 152.00 | 129.00 | 98.00 | 15.00 | 3.80 | 3.80 | 3.70 | 2.30 |
| Huawei | eMBB UE | 62.50 | 41.17 | 27.56 | \ | 19.05 | 12.09 | 9.63 | \ | 5.02 | 4.95 | 4.63 | \ |
| RedCap UE | \ | 19.16 | 16.93 | 30.57 | \ | 6.01 | 5.09 | 8.77 | \ | 3.85 | 2.96 | 3.15 |
| All UEs | 62.50 | 35.29 | 23.35 | 30.57 | 19.05 | 10.27 | 7.58 | 8.77 | 5.02 | 4.63 | 3.86 | 3.15 |
| vivo | eMBB UE | 419.32 | 426.57 | 422.85 |  | 143.05 | 149.96 | 152.43 |  | 4.35 | 4.54 | 4.68 |  |
| RedCap UE | \ | 33.70 | 33.33 |  | \ | 9.71 | 12.22 |  | \ | 1.86 | 1.95 |  |
| All UEs | 419.32 | 415.80 | 393.03 |  | 143.05 | 99.24 | 33.11 |  | 4.35 | 4.50 | 4.55 |  |
| Qualcomm | eMBB UE | 118.95 | 155.56 | 189.03 | \ | 44.27 | 52.85 | 77.25 | \ | 7.62 | 8.54 | 9.30 | \ |
| RedCap UE | \ | 20.64 | 28.90 | 34.61 | \ | 1.63 | 1.51 | 1.81 | \ | 5.55 | 5.19 | 8.47 |
| All UEs | 118.95 | 118.55 | 82.69 | 34.61 | 44.27 | 5.85 | 2.29 | 1.81 | 7.62 | 7.46 | 7.02 | 8.47 |
| Nokia | eMBB UE | 371.06 | 488.87 | 494.21 | \ | 173.15 | 255.53 | 273.74 | \ | 4.34 | 5.50 | 5.50 | \ |
| RedCap UE | \ | 44.28 | 44.76 | 44.36 | \ | 15.36 | 17.94 | 16.79 | \ | 2.07 | 2.07 | 2.07 |
| All UEs | 371.06 | 431.70 | 95.22 | 44.36 | 173.15 | 28.19 | 22.97 | 16.79 | 4.34 | 4.64 | 3.79 | 2.07 |

**Table 4-8: Downlink capacity evaluation for burst traffic (4GHz, low loading, 1Rx RedCap UE)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **4 GHz, DL, 1Rx RedCap, low loading (RU<30%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson | eMBB UE | 507.00 | 505.00 | 516.00 | \ | 151.00 | 154.00 | 156.00 | \ | 3.80 |  |  | \ |
| RedCap UE | \ | 49.00 | 50.00 | 50.00 | \ | 10.00 | 11.00 | 11.00 | \ |  |  | 1.60 |
| All UEs | 507.00 | 503.00 | 511.00 | 50.00 | 151.00 | 132.00 | 95.00 | 11.00 | 3.80 | 3.80 | 3.70 | 1.60 |
| Huawei | eMBB UE | 62.50 | 30.85 | 18.67 | \ | 19.05 | 8.71 | 5.08 | \ | 5.02 | 4.56 | 4.34 | \ |
| RedCap UE | \ | 9.59 | 10.59 | 12.74 | \ | 2.54 | 2.53 | 2.49 | \ | 2.24 | 1.94 | 1.86 |
| All UEs | 62.50 | 25.65 | 14.82 | 12.74 | 19.05 | 7.26 | 3.95 | 2.49 | 5.02 | 3.98 | 3.19 | 1.86 |
| vivo | eMBB UE | 422.64 | 420.15 | 413.95 |  | 146.07 | 141.29 | 150.78 |  | 4.51 | 4.50 | 4.45 |  |
| RedCap UE | \ | 31.52 | 30.67 |  | \ | 10.15 | 10.62 |  | \ | 1.75 | 1.70 |  |
| All UEs | 422.64 | 409.41 | 383.94 |  | 146.07 | 84.44 | 29.75 |  | 4.51 | 4.45 | 4.31 |  |
| Qualcomm | eMBB UE | 118.95 | 167.35 | 197.97 | \ | 44.27 | 60.54 | 80.16 | \ | 7.62 | 8.69 | 9.53 | \ |
| RedCap UE | \ | 15.22 | 15.84 | 19.22 | \ | 0.62 | 0.66 | 0.76 | \ | 2.59 | 2.74 | 3.07 |
| All UEs | 118.95 | 120.11 | 58.11 | 19.22 | 44.27 | 2.45 | 1.05 | 0.76 | 7.62 | 7.16 | 6.14 | 3.07 |
| Nokia | eMBB UE | 371.06 | 488.87 | 494.21 | \ | 173.15 | 255.53 | 273.74 | \ | 4.34 | 5.50 | 5.50 | \ |
| RedCap UE | \ | 35.20 | 34.83 | 34.78 | \ | 11.57 | 11.57 | 11.94 | \ | 1.48 | 1.48 | 1.48 |
| All UEs | 371.06 | 431.72 | 47.61 | 34.78 | 173.15 | 20.44 | 14.92 | 11.94 | 4.34 | 4.49 | 3.49 | 1.48 |

**Table 4-9: Downlink capacity evaluation for burst traffic (4GHz, medium loading, 2Rx RedCap UE)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **4 GHz, DL, 2Rx RedCap, medium loading (30%<RU<50%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson | eMBB UE | 404.00 | 393.00 | 417.00 | \ | 109.00 | 114.00 | 116.00 | \ | 3.80 |  |  | \ |
| RedCap UE | \ | 49.00 | 50.00 | 48.00 | \ | 11.00 | 12.00 | 9.00 | \ |  |  | 2.10 |
| All UEs | 404.00 | 409.00 | 414.00 | 48.00 | 109.00 | 104.00 | 84.00 | 9.00 | 3.80 | 3.70 | 3.60 | 2.10 |
| Huawei | eMBB UE | 43.48 | 50.00 | 20.13 | \ | 11.30 | 6.81 | 4.88 | \ | 5.14 | 5.04 | 4.61 | \ |
| RedCap UE | \ | 407.00 | 13.57 | 18.69 | \ | 3.81 | 2.51 | 3.88 | \ | 3.57 | 3.60 | 3.86 |
| All UEs | 43.48 | 26.43 | 16.93 | 18.69 | 11.30 | 6.25 | 3.75 | 3.88 | 5.14 | 4.58 | 4.12 | 3.86 |
| vivo | eMBB UE | 336.94 | 337.24 | 339.47 |  | 78.86 | 82.85 | 82.10 |  | 4.12 | 4.24 | 4.25 |  |
| RedCap UE | \ | 22.91 | 21.69 |  | \ | 5.95 | 5.59 |  | \ | 1.95 | 1.82 |  |
| All UEs | 336.94 | 323.63 | 305.21 |  | 78.86 | 45.98 | 20.18 |  | 4.12 | 4.20 | 4.14 |  |
| Qualcomm | eMBB UE |  | 132.23 | 166.67 | \ |  | 46.88 | 67.67 | \ |  | 7.61 | 8.24 | \ |
| RedCap UE |  | 16.41 | 22.80 | 34.61 |  | 1.21 | 1.20 | 1.81 |  | 3.81 | 4.23 | 8.47 |
| All UEs |  | 100.31 | 74.07 | 34.61 |  | 3.97 | 1.87 | 1.81 |  | 6.66 | 6.24 | 8.47 |
| Nokia | eMBB UE | 159.15 | 319.16 | 371.27 | \ | 28.26 | 137.36 | 174.61 | \ | 2.68 | 3.82 | 4.34 | \ |
| RedCap UE | \ | 15.60 | 18.75 | 19.66 | \ | 2.32 | 3.15 | 3.35 | \ | 1.21 | 1.25 | 1.25 |
| All UEs | 159.15 | 249.19 | 95.10 | 19.66 | 28.26 | 6.38 | 4.97 | 3.35 | 2.68 | 3.17 | 2.80 | 1.25 |

**Table 4-10: Downlink capacity evaluation for burst traffic (4GHz, medium loading, 1Rx RedCap UE)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **4 GHz, DL, 1Rx RedCap, medium loading (30%<RU<50%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson | eMBB UE | 404.00 | 408.00 | 412.00 | \ | 109.00 | 112.00 | 110.00 | \ | 3.80 |  |  | \ |
| RedCap UE | \ | 39.00 | 39.00 | 38.00 | \ | 7.00 | 8.00 | 7.00 | \ |  |  | 1.70 |
| All UEs | 404.00 | 407.00 | 406.00 | 38.00 | 109.00 | 102.00 | 74.00 | 7.00 | 3.80 | 3.60 | 3.50 | 1.70 |
| Huawei | eMBB UE | 43.48 | 18.72 | 12.25 | \ | 11.30 | 4.08 | 2.54 | \ | 5.14 | 5.06 | 5.04 | \ |
| RedCap UE | \ | 9.82 | 9.28 | 10.93 | \ | 2.45 | 1.48 | 1.66 | \ | 2.33 | 2.96 | 3.22 |
| All UEs | 43.48 | 16.60 | 10.51 | 10.93 | 11.30 | 3.68 | 1.90 | 1.66 | 5.14 | 4.20 | 3.67 | 3.22 |
| vivo | eMBB UE | 343.43 | 337.71 | 341.72 |  | 83.67 | 79.37 | 81.73 |  | 4.32 | 4.15 | 4.25 |  |
| RedCap UE | \ | 20.95 | 20.12 |  | \ | 4.64 | 4.73 |  | \ | 1.59 | 1.67 |  |
| All UEs | 343.43 | 324.09 | 306.91 |  | 83.67 | 42.09 | 18.41 |  | 4.32 | 4.09 | 4.13 |  |
| Qualcomm | eMBB UE |  | 137.93 | 170.21 | \ |  | 52.77 | 69.00 | \ |  | 7.59 | 8.42 | \ |
| RedCap UE |  | 12.64 | 13.12 | 19.22 |  | 0.58 | 0.59 | 0.76 |  | 2.45 | 2.53 | 3.07 |
| All UEs |  | 102.89 | 55.35 | 19.22 |  | 1.75 | 0.67 | 0.76 |  | 6.31 | 5.47 | 3.07 |
| Nokia | eMBB UE | 159.15 | 319.16 | 371.27 | \ | 28.26 | 137.36 | 174.61 | \ | 2.68 | 3.82 | 4.34 | \ |
| RedCap UE | \ | 13.51 | 17.46 | 22.20 | \ | 1.89 | 2.92 | 4.73 | \ | 1.12 | 1.12 | 1.16 |
| All UEs | 159.15 | 249.20 | 95.10 | 22.20 | 28.26 | 4.36 | 4.04 | 4.73 | 2.68 | 3.15 | 2.73 | 1.16 |

**Table 4-11: Uplink capacity evaluation for burst traffic (4GHz, low loading)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **4 GHz, UL, low loading (RU<30%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson | eMBB UE | 52.000 | 52.000 | 52.000 | \ | 0.900 | 0.900 | 0.900 | \ | 0.40 |  |  | \ |
| RedCap UE | \ | 16.000 | 16.000 | 16.000 | \ | 0.800 | 0.900 | 0.700 | \ |  |  | 0.50 |
| All UEs | 52.000 | 52.000 | 51.000 | 16.000 | 0.900 | 0.900 | 0.900 | 0.700 | 0.40 | 0.40 | 0.40 | 0.50 |
| Huawei | eMBB UE | 9.850 |  | 4.240 | \ | 0.210 |  | 0.240 | \ | 1.48 |  | 1.45 | \ |
| RedCap UE | \ |  | 2.330 | 5.110 | \ |  | 0.200 | 0.240 | \ |  | 0.75 | 0.78 |
| All UEs | 9.850 |  | 3.290 | 5.110 | 0.210 |  | 0.200 | 0.240 | 1.48 |  | 1.07 | 0.78 |
| vivo | eMBB UE | 12.845 | 12.574 | 12.369 |  | 0.058 | 0.057 | 0.057 |  | 1.34 | 1.34 | 1.34 |  |
| RedCap UE | \ | 0.582 | 0.635 |  | \ | 0.065 | 0.070 |  | \ | 0.32 | 0.32 |  |
| All UEs | 12.845 | 1.325 | 2.544 |  | 0.058 | 0.057 | 0.058 |  | 1.34 | 1.26 | 1.16 |  |
| Nokia | eMBB UE | 63.987 | 61.527 | 63.484 | \ | 11.134 | 27.863 | 28.981 | \ | 0.73 | 0.72 | 0.73 | \ |
| RedCap UE | \ | 11.065 | 11.141 | 9.399 | \ | 7.803 | 8.291 | 7.987 | \ | 0.58 | 0.59 | 0.59 |
| All UEs | 63.987 | 51.601 | 13.084 | 9.399 | 11.134 | 9.623 | 8.852 | 7.987 | 0.73 | 0.69 | 0.66 | 0.59 |

**Table 4-12: Uplink capacity evaluation for burst traffic (4GHz, medium loading)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **4 GHz, UL, medium loading (30%<RU<50%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson | eMBB UE | 43.000 | 43.000 | 43.000 | \ | 0.600 | 0.600 | 0.600 | \ | 0.60 |  |  | \ |
| RedCap UE | \ | 15.000 | 15.000 | 15.000 | \ | 0.500 | 0.500 | 0.500 | \ |  |  | 0.60 |
| All UEs | 43.000 | 42.000 | 41.000 | 15.000 | 0.600 | 0.600 | 0.600 | 0.500 | 0.60 | 0.60 | 0.60 | 0.60 |
| Huawei | eMBB UE | 8.450 | 6.110 | 4.070 | \ | 0.200 | 0.220 | 0.220 | \ | 1.86 | 2.20 | 2.05 | \ |
| RedCap UE | \ | 2.840 | 2.410 | 3.790 | \ | 0.200 | 0.200 | 0.220 | \ | 0.73 | 0.89 | 1.25 |
| All UEs | 8.450 | 5.220 | 3.260 | 3.790 | 0.200 | 0.200 | 0.200 | 0.220 | 1.86 | 1.67 | 1.42 | 1.25 |
| vivo | eMBB UE | 5.265 | 5.894 | 4.805 |  | 0.058 | 0.058 | 0.058 |  | 1.34 | 1.34 | 1.32 |  |
| RedCap UE | \ | 0.505 | 0.513 |  | \ | 0.034 | 0.037 |  | \ | 0.32 | 0.32 |  |
| All UEs | 5.265 | 2.976 | 1.217 |  | 0.058 | 0.057 | 0.056 |  | 1.34 | 1.27 | 1.17 |  |
| Nokia | eMBB UE | 54.438 | 54.020 | 53.324 | \ | 22.083 | 20.970 | 20.970 | \ | 0.70 | 0.70 | 0.70 | \ |
| RedCap UE | \ | 10.469 | 10.527 | 10.538 | \ | 5.873 | 6.004 | 5.873 | \ | 0.58 | 0.58 | 0.58 |
| All UEs | 54.438 | 42.751 | 12.042 | 10.538 | 22.083 | 8.429 | 7.260 | 5.873 | 0.70 | 0.67 | 0.64 | 0.58 |

**Table 4-13: Downlink capacity evaluation for burst traffic (28 GHz, low loading, 2Rx RedCap UE)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **28 GHz, DL, 2Rx RedCap, low loading (RU<30%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson | eMBB UE | 441.00 | 444.00 | 442.00 | \ | 192.00 | 199.00 | 198.00 | \ | 8.80 |  |  | \ |
| RedCap UE | \ | 338.00 | 336.00 | 356.00 | \ | 153.00 | 146.00 | 155.00 | \ |  |  | 7.00 |
| All UEs | 441.00 | 442.00 | 440.00 | 356.00 | 192.00 | 199.00 | 195.00 | 155.00 | 8.80 | 8.70 | 8.60 | 7.00 |
| MTK | eMBB UE | 103 |  |  | \ | 51 |  |  | \ | 4.14 |  |  | \ |
| RedCap UE | \ |  |  | 64.00 | \ |  |  | 44.00 | \ |  |  | 2.70 |
| All UEs | 103 |  |  | 64.00 | 51 |  |  | 44.00 | 4.14 |  |  | 2.70 |
| Qualcomm | eMBB UE | 322.50 | 334.80 | 323.00 | \ | 286.30 | 313.20 | 290.30 | 318.60 | 6.90 | 6.90 | 6.90 | \ |
| RedCap UE | \ | 312.90 | 306.80 | 328.70 | \ | 267.50 | 266.00 | \ | \ | 6.80 | 6.90 | 6.90 |
| All UEs | 322.50 | 327.30 | 316.50 | 328.70 | 286.30 | 285.70 | 277.40 | 318.60 | 6.90 | 6.90 | 6.90 | 6.90 |

**Table 4-14: Downlink capacity evaluation for burst traffic (28 GHz, low loading, 1Rx RedCap UE)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **28 GHz, DL, 1Rx RedCap, low loading (RU<30%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson | eMBB UE | 441.00 | 445.00 | 437.00 | \ | 192.00 | 202.00 | 196.00 | \ | 8.80 |  |  | \ |
| RedCap UE | \ | 215.00 | 213.00 | 213.00 | \ | 103.00 | 100.00 | 98.00 | \ |  |  | 4.40 |
| All UEs | 441.00 | 444.00 | 434.00 | 213.00 | 192.00 | 199.00 | 189.00 | 98.00 | 8.80 | 8.70 | 8.40 | 4.40 |
| MTK | eMBB UE | 103.00 |  |  | \ | 51.00 |  |  | \ | 4.14 |  |  | \ |
| RedCap UE | \ |  |  | 48.00 | \ |  |  | 22.00 | \ |  |  | 2.2 |
| All UEs | 103.00 |  |  | 48.00 | 51.00 |  |  | 22.00 | 4.14 |  |  | 2.2 |
| Qualcomm | eMBB UE |  |  |  | \ |  |  |  | \ |  |  |  | \ |
| RedCap UE |  |  |  | 177.30 |  |  |  | 172.00 |  |  |  | 3.50 |
| All UEs |  |  |  | 177.30 |  |  |  | 172.00 |  |  |  | 3.50 |

**Table 4-15: Downlink capacity evaluation for burst traffic (28 GHz, medium loading, 2Rx RedCap UE)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **28 GHz, DL, 2Rx RedCap, medium loading (30%<RU<50%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson | eMBB UE | 322.00 | 344.00 | 347.00 | \ | 109.00 | 133.00 | 134.00 | \ | 8.60 |  |  | \ |
| RedCap UE | \ | 244.00 | 244.00 | 238.00 | \ | 89.00 | 91.00 | 79.00 | \ |  |  | 6.30 |
| All UEs | 322.00 | 344.00 | 344.00 | 238.00 | 109.00 | 133.00 | 133.00 | 79.00 | 8.60 | 8.50 | 8.20 | 6.30 |
| MTK | eMBB UE | 84 |  |  | \ | 38.00 |  |  | \ | 3.75 |  |  | \ |
| RedCap UE | \ |  |  | 54.00 | \ |  |  | 32.00 | \ |  |  | 2.60 |
| All UEs | 84 |  |  | 54.00 | 38.00 |  |  | 32.00 | 3.75 |  |  | 2.60 |
| Qualcomm | eMBB UE | 249.50 | 284.00 | 237.80 |  | 207.70 | 238.10 | 189.00 |  | 6.80 | 6.80 | 6.70 |  |
| RedCap UE | \ | 272.20 | 228.60 |  | \ | 237.00 | 156.90 |  | \ | 6.80 | 6.60 |  |
| All UEs | 249.50 | 283.00 | 234.80 |  | 207.70 | 238.60 | 167.40 |  | 6.80 | 6.80 | 6.60 |  |

**Table 4-16: Downlink capacity evaluation for burst traffic (28 GHz, medium loading, 1Rx RedCap UE)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **28 GHz, DL, 1Rx RedCap, medium loading (30%<RU<50%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson | eMBB UE | 322.00 | 343.00 | 346.00 | \ | 109.00 | 130.00 | 132.00 | \ | 8.60 |  |  | \ |
| RedCap UE | \ | 172.00 | 171.00 | 173.00 | \ | 64.00 | 63.00 | 65.00 | \ |  |  | 4.40 |
| All UEs | 322.00 | 342.00 | 342.00 | 173.00 | 109.00 | 128.00 | 128.00 | 65.00 | 8.60 | 8.40 | 8.00 | 4.40 |
| MTK | eMBB UE | 84.00 |  |  | \ | 38.00 |  |  | \ | 3.75 |  |  | \ |
| RedCap UE | \ |  |  | 35.00 | \ |  |  | 11.00 | \ |  |  | 1.90 |
| All UEs | 84.00 |  |  | 35.00 | 38.00 |  |  | 11.00 | 3.75 |  |  | 1.90 |

**Table 4-17: Uplink capacity evaluation for burst traffic (28 GHz, low loading)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **28 GHz, UL, low loading (RU<30%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson | eMBB UE | 62.00 | 62.00 | 61.00 | \ | 16.00 | 16.00 | 16.00 | \ | 1.10 |  |  | \ |
| RedCap UE | \ | 54.00 | 53.00 | 49.00 | \ | 14.00 | 14.00 | 10.00 | \ |  |  | 0.90 |
| All UEs | 62.00 | 62.00 | 61.00 | 49.00 | 16.00 | 16.00 | 16.00 | 10.00 | 1.10 | 1.10 | 1.00 | 0.90 |
| MTK | eMBB UE | 72.00 |  |  | \ | 47.00 |  |  | \ | 0.82 |  |  | \ |
| RedCap UE | \ |  |  | 31.00 | \ |  |  | 20.00 | \ |  |  | 0.40 |
| All UEs | 72.00 |  |  | 31.00 | 47.00 |  |  | 20.00 | 0.82 |  |  | 0.40 |

**Table 4-18: Uplink capacity evaluation for burst traffic (28 GHz, medium loading)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **28 GHz, UL, medium loading (30%<RU<50%)** | | | | | | | | | | | | | |
|  |  | 50% UPT (Mbps) | | | | 5% UPT (Mbps) | | | | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% | 0 | 25% | 50% | 100% |
| Ericsson | eMBB UE | 31.00 | 31.00 | 31.00 | \ | 0.60 | 0.60 | 0.60 | \ | 1.10 |  |  | \ |
| RedCap UE | \ | 27.00 | 27.00 | 18.00 | \ | 0.50 | 0.50 | 0.10 | \ |  |  | 0.80 |
| All UEs | 31.00 | 31.00 | 31.00 | 18.00 | 0.60 | 0.60 | 0.60 | 0.10 | 1.10 | 1.00 | 1.00 | 0.80 |
| MTK | eMBB UE | 53.00 |  |  | \ | 38.00 |  |  | \ | 0.80 |  |  | \ |
| RedCap UE | \ |  |  | 22.50 | \ |  |  | 8.50 | \ |  |  | 0.40 |
| All UEs | 53.00 |  |  | 22.50 | 38.00 |  |  | 8.50 | 0.80 |  |  | 0.40 |

**Table 4-19: Downlink capacity evaluation for full buffer traffic (2.6 GHz, 2Rx RedCap UE)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **2.6GHz, DL, 2Rx RedCap, full buffer, total 10 UEs/cell** | | | | | |
|  |  | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 20% | 50% | 100% |
| Huawei | eMBB UE | 15.10 | 14.92 | 14.48 | \ |
| RedCap UE | \ | 9.63 | 9.84 | 10.50 |
| All UEs | 15.10 | 14.18 | 12.80 | 10.50 |
| Nokia | eMBB UE | 4.49 | 4.47 | 4.43 | \ |
| RedCap UE | \ | 2.67 | 2.77 | 2.84 |
| All UEs | 4.49 | 4.11 | 3.60 | 2.84 |

**Table 4-20: Downlink capacity evaluation for full buffer traffic (2.6 GHz, 1Rx RedCap UE)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **2.6 GHz, DL, 1Rx RedCap, full buffer, total 10 UEs/cell** | | | | | |
|  |  | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 20% | 50% | 100% |
| Huawei | eMBB UE | 15.10 | 15.03 | 14.87 | \ |
| RedCap UE | \ | 7.68 | 7.80 | 7.87 |
| All UEs | 15.10 | 13.65 | 11.49 | 7.87 |
| Nokia | eMBB UE | 4.49 | 4.47 | 4.43 | \ |
| RedCap UE | \ | 2.09 | 2.17 | 2.21 |
| All UEs | 4.49 | 3.99 | 3.30 | 2.21 |

**Table 4-21: Uplink capacity evaluation for full buffer traffic (2.6 GHz)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **2.6 GHz, UL, full buffer, total 10 UEs/cell** | | | | | |
|  |  | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 20% | 50% | 100% |
| Huawei | eMBB UE | 2.73 | 2.70 | 2.61 | \ |
| RedCap UE | \ | 1.41 | 1.49 | 1.54 |
| All UEs | 2.73 | 2.47 | 2.14 | 1.54 |
| Nokia | eMBB UE | 2.03 | 2.01 | 2.00 | \ |
| RedCap UE | \ | 1.79 | 1.78 | 1.79 |
| All UEs | 2.03 | 1.97 | 1.89 | 1.79 |

**Table 4-22: Downlink capacity evaluation for full buffer traffic (4 GHz, 2Rx RedCap UE)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **4 GHz, DL, 2Rx RedCap, full buffer, total 10 UEs/cell** | | | | | |
|  |  | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 20% | 50% | 100% |
| Huawei | eMBB UE | 14.02 | 13.96 | 13.66 | \ |
| RedCap UE | \ | 9.14 | 9.43 | 9.68 |
| All UEs | 14.02 | 14.18 | 12.80 | 9.68 |
| Nokia | eMBB UE | 4.74 | 4.73 | 4.75 | \ |
| RedCap UE | \ | 2.98 | 2.89 | 2.89 |
| All UEs | 4.74 | 4.38 | 3.82 | 2.89 |

**Table 4-23: Downlink capacity evaluation for full buffer traffic (4 GHz, 1Rx RedCap UE)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **2.6GHz, DL, 1Rx RedCap, full buffer, total 10 UEs/cell** | | | | | |
|  |  | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 20% | 50% | 100% |
| Huawei | eMBB UE | 14.02 | 13.88 | 13.65 | \ |
| RedCap UE | \ | 6.76 | 6.92 | 7.14 |
| All UEs | 14.02 | 12.91 | 10.75 | 7.14 |
| Nokia | eMBB UE | 4.74 | 4.73 | 4.75 | \ |
| RedCap UE | \ | 2.25 | 2.20 | 2.21 |
| All UEs | 4.74 | 4.23 | 3.47 | 2.21 |

**Table 4-24: Uplink capacity evaluation for full buffer traffic (4 GHz)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **2.6GHz, UL, full buffer, total 10 UEs/cell** | | | | | |
|  |  | Cell avg. SE (bps/Hz) | | | |
|  | RedCap UE ratio | 0 | 20% | 50% | 100% |
| Huawei | eMBB UE | 2.54 | 2.49 | 2.41 | \ |
| RedCap UE | \ | 1.35 | 1.41 | 1.47 |
| All UEs | 2.54 | 2.47 | 2.14 | 1.47 |
| Nokia | eMBB UE | 1.94 | 1.93 | 1.93 | \ |
| RedCap UE | \ | 1.76 | 1.76 | 1.75 |
| All UEs | 1.94 | 1.90 | 1.84 | 1.75 |

**Question 4-1: Can the SLS evaluation results in Table 4-1 to Table 4-24 be captured to TR 38.875? (Companies are invited for check the results and if any modification is needed, please also indicate here.)**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo |  | We would like to have some discussion on the different simulation assumptions used in the evaluation first.  For example, we found that some agreed evaluation assumption were not followed by companies   1. For traffic model, it was agreed to use IM traffic model (TR38.840) for RedCap UEs, however, different traffic model were used, e.g. in Huawei’s evaluation 2. For simulated BW, it was agreed to simulate 100MHz for eMBB UEs and 20MHz for RedCap UEs in FR1, however, different BW assumptions were used, e.g. in Huawei’s evaluation, 20MHz was used for both eMBB and RedCap UEs. |
| Futurewei | Y | It is important to capture the results to address the operator concerns. |
| Ericsson |  | We think we can give more time for companies to update the results. Ericsson plans to update our results based on more sufficient collection of statistics.  We note that in the 50% UPT (Mbps) results reported by most companies are quite low for the eMBB UEs. Note that in FR1 the eMBB UEs has 100 MHz BW, 256QAM and MIMO so that the peak data rate is > 1 Gbps.  In the tables “Redap” should be changed to “RedCap”.  It might be better to have separate tables for different traffic assumptions (or add a clarifying note on this). |
| Samsung |  | It should be clearly stated if simulation assumptions different than what was agreed are used for some simulation results. |
| Huawei, Hisilicon |  | In response to Vivo’s comments on our evaluation assumption, firstly, we encourage all companies to share more their SLS assumptions that have not been covered by agreements and we confirmed that our traffic model and scheduled bandwidth assumptions are in line with current agreements. Please find more details below,   1. For the traffic model   Instant message traffic model is only agreed for power saving evaluation, while for Capacity impact evaluation, it was agreed that both FTP 3 and Instant message can be considered for RedCap UEs.  The related agreements are provided as following:  *Agreements:*  *For power saving evaluation of RedCap UEs:*   * *Reuse the Instant message traffic model from TR 38.840 as baseline. Other ~~Instant~~ traffic models based on FTP model 3 are not precluded and companies to report the mean inter-arrival time and packet size if other ~~instant~~ traffic models are assumed in evaluation.* * *FFS: ‘heartbeat’ traffic model*   *Agreements:*   * *For SLS based capacity evaluation, use the assumption in TR 38.802, Table A.2.1-1 as the baseline.* * *For calibration purposes, the following settings can be used:*  |  |  |  | | --- | --- | --- | | ***Parameters*** | ***FR1 values*** | ***FR2 values*** | | *Layout* | *Single layer Macro layer: Hex. Grid* | *Single layer*  *Indoor floor: (12BSs per 120m x 50m)*  *Candidate TRP numbers: 3, 6, 12* | | *Inter-BS distance* | *500m* | *20m* | | *Scenario and frequency* | *Dense Urban:*  *2.6 GHz (TDD) (primary choice)*  *4 GHz (TDD) (secondary choice)*  *Other scenarios (e.g. Rural 700MHz) are not precluded.* | *Indoor: 28 GHz (TDD)* | | *Frame structure for TDD* | *For 2.6 GHz:*  *DDDDDDDSUU (S: 6D:4G:4U)*  *For 4 GHz:*  *DDDSUDDSUU (S: 10D:2G:2U)* | *DDDSU (S: 10D:2G:2U)* | | *Channel model* | *3Duma* | *5GCM office* | | *UE distribution* | *20% Outdoor in cars: 30km/h, 80% Indoor in houses: 3km/h* | *100% Indoor: 3km/h* | | *Traffic model* | *Full buffer (Optional)*  *Non-full buffer traffic, e.g. FTP traffic model 3 for the reference NR UEs and the IM traffic model from TR 38.840 for RedCap UEs* | | | *Traffic load* | *Full buffer traffic (Optional):*  *10 users per cell including both RedCap and reference NR UEs*  *Non-full buffer traffic:*  *Low (e.g. <30%) and medium (e.g. 30%-50%) loading (resource utilization)* | | | *Percentage of RedCap UEs among total number of UEs*  *Note: Other UEs are the reference NR UEs* | *Full buffer traffic (Optional):*  *0, 20%, 50% (i.e. 0, 2 or 5 RedCap UEs per cell), 100% (as applicable)*  *Non-full buffer traffic:*  *0, 25%, 50%, ~~[100%]~~ 100% (optional, as applicable)* | |  1. For the scheduled bandwidths   The following agreements have been made in RedCapCapacity template’s general note, where the scheduled BW is up to 100MHz, not fixed 100MHz. More importantly, the traffic data rate for non-full buffer is not agreed yet, neither the way to scattering out 20MHz REDCAP within 100MHz bandwidth. To complete the assumptions, the following assumptions are used,   * The DL traffic data rate is proportional to UE bandwidth: 25Mbps DL@100MHz for reference UE, 5Mbps DL@20MHz for RedCap UE, with 5:1 ratio between two kinds of UEs. * No frequency hopping for RedCap UE: every RedCap UE is fixed to one of five 20MHz frequency blocks within 100MHz bandwidth. Different RedCap UEs are scattered out within 100MHz bandwidth. As a result, RedCap UEs in different frequency blocks do not compete each other for raido resources but compete only with RedCap UEs and Reference UEs scheduled in the same frequency blocks. * RU is the same for all 20MHz frequency blocks as RU definition.   Since the UPT of a RedCap UEs in one frequency block are impacted by reference UEs only when reference UE’s traffic falls into the frequency block, we call that the scheduled bandwidth for reference UE is 20Mhz and its equivalent DL traffic data rate of reference UEs within the 20MHz frequency block is also 5Mbps.  *Agreements:*  *8. The total system bandwidth in the SLS can be 100 MHz for both FR1 and FR2 (aligned with the LLS assumption).*  *In FR1, the scheduled bandwidths for eMBB and RedCap UEs can be up to 100 MHz and 20 MHz, respectively. In FR2, the scheduled bandwidths for eMBB UEs can be up to 100 MHz, and up to 100 MHz or 50 MHz for RedCap UEs.*  Secondly, we also provide SLS results of SE and RU for non-full buffer traffic. Our above assumptions obviously have no impact on SE and RU evaluation.  Thirdly, in our view, the key in Capacity evaluation is the traffic model.The use cases discussed in SID include Video surveillance, wearables and IWSN. So Video is a more typical traffic than Instant message, while we have noted that in some companies’ assumption, such as Vivo, FTP3 and IM are considered for reference UEs and RedCap UEs, which means the traffic contribution by RedCap UEs and reference UEs is no more than 1:50. With such low traffic contribution from RedCap UEs, the impact from RedCap UEs is obviously hard to be observed. It would be no surprise if no impact were observed.  Again, we would like to encourage all companies to share more their SLS assumptions that have not been covered by agreements, e.g. how to scatter out UEs, scheduling constraint. |
| FL4 | It is noted that companies have different assumptions on the traffic model and the simulation bandwidth resulting in very different observations.  As seen from capacity evaluation spreadsheet, three companies (vivo, Ericsson, Qualcomm) use the IM model for RedCap and FTP3 for the eMBB UE, and other companies (Huawei, MTK, Nokia) use the FTP3 for both RedCap and eMBB UEs. It is also noted that even with FTP3, the assumptions for packet size and mean inter-arrival time are different by companies.  In case of FTP3 for both RedCap and eMBB UEs, we also note different observations from companies’ evaluation results for the impact to eMBB UE UPT with presence of RedCap UE.  Therefore, the FL would like to encourage companies to share more on the SLS assumptions, e.g. packet size and mean inter-arrival time for FTP3 and IM model, scheduling bandwidth, the number of eMBB and RedCap UEs, etc. Also, companies are invited to provide input whether and how to use the evaluation results for making summary observation | |
| vivo |  | Our simulation assumptions  Traffic model: (according to RAN1#102e agreement)   * FTP traffic model 3 from TR38.840 for eMBB UEs * IM traffic model from TR 38.840 for RedCap Ues   Scheduling BW: (according to RAN1 agreement made in post RAN1#102e email discussion)   * 100MHz for eMBB UE (FR1) * 20MHz for RedCap UE(FR1)   Number of UEs: reported in the excel sheet |
| Ericsson |  | * Regarding traffic model we assume the following:   + [FTP3](ftp://FTP3): 0.5 MB payload every 200ms. => 2e7 bits/s per MBB UE   + IM: 0.1 MB payload every 2s. => 4e5 bits/s per RedCap UE. * For both RedCap and reference MBB UEs the number of MIMO layers in DL is assumed to be same the number of Rx antennas. * Power control is used in the uplink. * No carrier-aggregation is used. * MU MIMO scheduling is used for DL. * Option 1 is used, i.e. constant RU is compared for the different RedCap user fractions. That is, 30% RU for 100% MBB corresponds to a larger offered load than 30% RU for RedCap since RedCap transmission is less efficient. * Traffic assumed to be symmetric in UL and DL. * Simulation parameters:  |  |  |  | | --- | --- | --- | | **Case:** | 2.6 GHz | 28 GHz | | **System BW:** | 100 MHz | 100 MHz | | **Ref UE:** | 100 MHz  4Rx  Max 256QAM in DL  Max 64QAM in UL | 100 MHz  2Rx  Max 64QAM in DL  Max 64QAM in UL | | **RedCap UE:** | 20 MHz  1Rx or 2Rx  Max 64QAM in DL  Max 16QAM in UL | 100 MHz  1Rx or 2Rx  Max 16QAM in DL  Max 16QAM in UL | |
| **FL5** | FL note: The clarification notes on evaluation assumptions have been added to some tables of low-loading and medium-loading. The numbers in the tables have been updated also based on the latest evaluation results in the version v012.  Based on the received response, the FL’s updated suggestion is as following.  **[FL5] Updated Proposal 4-1:**   * Capture the SLS evaluation results in Table 4-1 to Table 4-24 to TR 38.875   + The tables will be further updated with potential updated evaluation results (to catch potential typos) and a clarification of evaluation assumption   + Up to editor to decide whether to include evaluation assumption notes to all the tables. | |
| vivo |  | Fine in general. Regarding the Notes (detailed assumptions), we propose to clarify if the agreed evaluation assumption (e.g. traffic model, schedulable BW) are followed or not. Otherwise, it seems difficult to directly compare the results from companies. |

***Summary of observations:***

For burst traffic evaluation, the assumed traffic model for RedCap UE is different by companies. In contributions [1, 4, 24], the IM model as defined in TR 38.840 is used and the averaged traffic ratio between the reference eMBB and RedCap UEs is relatively small, e.g. less than 2%. The very low data volume in the downlink is corresponding to some RedCap use cases with UL dominant traffic, e.g. video surveillance and industrial wireless sensor. In contribution [3], FTP model 3 is used for both eMBB and RedCap UEs by considering some video applications for wearable and video surveillance use cases.

With different assumption of traffic model for RedCap, the impact of UE complexity reduction on network capacity and spectrum efficiency could be different. The contributions [1, 4] have noted that RedCap UE may experience degraded performance due to cost reduction features, but there is little impact on the reference eMBB UE performance. The contribution [1] stated that the spectral efficiency in DL has a minor degradation with the introduction of small RedCap data volume even with a 50% fraction of RedCap users, and the spectral efficiency in UL is essentially unchanged. The contribution [4] noted that the introduction of RedCap UEs has little impact to the co-existing eMBB UEs in the system and the cell capacity (cell served throughput) is increased due to the introduction of RedCap UEs to the system. The contributions [1, 24] also noted that for the impact of UE complexity reduction, the 1 Rx antenna does not make an appreciable change on the user throughput performance of the eMBB UE compared to the 2 Rx antenna.

With FTP model 3 for RedCap UE, the contribution [3] stated that the loss of downlink SE is about 54% and RU is increased by 104% for 2 Rx RedCap UE and the SE loss will be up to 70% and RU will be increased by 166% if UE Rx antenna is further reduced to 1Rx for the assumption of 100% RedCap UE in network.

Based on the SLS evaluation results in Table 4-1 to Table 4-24 and companies’ observations, the following observations are proposed for discussion for the TP drafting for TR 38.875.

**Moderator’s observation**

* P1: When the RedCap traffic volume is low (e.g. under the assumption of the IM model as defined in TR 38.840), there is little impact on eMBB UE performance and little impact on cell-average spectral efficiency
* P2: When the RedCap traffic volume is high (e.g. under the assumption of FTP model 3), there is a considerable degradation of cell-average spectral efficiency in downlink, especially for 1 Rx antenna
* P3: The loss of uplink capacity performance is much lower than in the downlink

**Question 4-2: Can the above list (P1-P3) be used as a baseline text for TR 38.875? If not, what other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo |  | As commented before, there are discrepancies in some key simulation parameters, e.g. traffic, BW, etc, which lead to different observations. We should address them first. |
| Futurewei | Y | It is important to capture the results to address the operator concerns. We are not OK to only capture P1 without P2 |
| Ericsson |  | P1: okay  P2: It should be clarified that the assumption is that a RedCap UE generates as much traffic as an eMBB UE. Then, in our view the degradation shown in the results is also due to the system load has increased when more and more RedCap UEs are added to the system. In our view, this is the main cause of the degradation.  P3: okay |
| Samsung |  | The comment in Q 4-1 should be addressed before agreeing it. |
| Huawei, Hisilicon |  | It is good to discuss traffic load and include its conclusion into the observation, e.g. the traffic contribution ratio of RedCap UEs, and the traffic load ratio of reference UE over RedCap UE. |

**[FL5] Based on the received response, the FL’s updated text proposals is as following.**

|  |
| --- |
| The SLS evaluations for the impacts of UE complexity reduction and antenna inefficiency to network capacity and spectrum efficiency are summarized in Table 4-1 to 4-24. Burst traffic model and optional full buffer traffic are considered.  For burst traffic evaluation, FTP model 3 is assumed for eMBB users. The assumption of traffic model for RedCap users varies across the sourcing companies. The instant message (IM) traffic model which in average generates an offered load of 4x105 bits/s (0.1 MB payload every 2 s) is assumed for RedCap users by some sourcing companies. Compared to the assumed traffic model for the eMBB users which have an offered load of 2x107 bits/s (0.5 MB payload every 200 ms), the RedCap users will produce a very low data volume even with a 50-50 split of eMBB and RedCap users. The use of IM traffic for downlink capacity evaluation corresponds to video surveillance and industrial wireless sensor use cases for which traffic pattern is dominated by UL transmissions.  Some companies have considered to reuse the same FTP model 3 for RedCap users by assuming wearable use cases have DL heavy traffic and the traffic pattern is the same for RedCap users and eMBB users. It should be noted that among the companies assuming FTP3 traffic model for RedCap, there may be differences in the average traffic volume assumption. Such a difference may contribute to different conclusion.  For burst traffic evaluation with IM traffic model for RedCap users:   * 3 sources observed that the RedCap users have minor or no impact on spectral efficiency and capacity, and little impact to the performance of co-existing eMBB users in the system * It is further noted that the 1 Rx RedCap users do not make an appreciable change on the user throughput performance of the eMBB users compared to the 2 Rx RedCap users   For burst traffic evaluation with FTP model 3 for RedCap users:   * One source reported the user throughput performance of the eMBB users is not degraded with the presence of the RedCap users in the system. * One source reported the impact on spectral efficiency will be substantial. It is further observed substantial cell spectral efficiency loss about 30% due to UE Rx antenna reduced from four to two and DL modulation order restriction from 256QAM to 64QAM in FR1 and about 50% spectral efficiency reduction due to UE Rx antenna reduced from four to one and DL modulation order restriction from 256QAM to 64QAM in FR1   For full buffer traffic evaluation:   * One source reported a minor degradation of the spectral efficiency for the eMBB users and the degree of spectral efficiency loss is irrespective of the number of Rx antennas for RedCap users * One source reported the impact on spectral efficiency will be substantial. It is further observed substantial cell spectral efficiency loss about 54% due to UE Rx antenna reduced from four to two and DL modulation order restriction from 256QAM to 64QAM in FR1 and about 70% spectral efficiency reduction due to UE Rx antenna reduced from four to one and DL modulation order restriction from 256QAM to 64QAM in FR1 |

**[FL5] Question 4-1A:** **Can the above observations of the impact to network capacity be used as a baseline text for TR 38.875? If not, what aspects to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo |  | Propose some revisions as below   1. Regarding traffic models   The instant message (IM) traffic model which in average generates an offered load of 4x105 bits/s (0.1 MB payload every 2 s) is assumed for RedCap users by some sourcing companies according to RAN1 agreement.  …  The use of IM traffic for downlink capacity evaluation corresponds to video surveillance and industrial wireless sensor use cases for which traffic pattern is dominated by UL transmissions. In addition, IM traffic may also be possible for some low data rate wearable use cases.   1. Regarding evaluation results, the following highlighted observation is based on the different schedulable BW assumption (20MHz for both eMBB and RedCap) compared to the RAN1 agreement (20MHz for RedCap, 100MHz for eMBB), we should clearly highlight such discrepancy from the agreed simulation assumption since that might be the true reason for the different observation compared to other sources. In addition, the fact that RAN1 agreed full buffer traffic evaluation being optional should also be captured.   For burst traffic evaluation with FTP model 3 for RedCap users:   * One source reported the user throughput performance of the eMBB users is not degraded with the presence of the RedCap users in the system. * One source reported the impact on spectral efficiency will be substantial. It is further observed substantial cell spectral efficiency loss about 30% due to UE Rx antenna reduced from four to two and DL modulation order restriction from 256QAM to 64QAM in FR1 and about 50% spectral efficiency reduction due to UE Rx antenna reduced from four to one and DL modulation order restriction from 256QAM to 64QAM in FR1   For full buffer traffic evaluation:   * One source reported a minor degradation of the spectral efficiency for the eMBB users and the degree of spectral efficiency loss is irrespective of the number of Rx antennas for RedCap users * One source reported the impact on spectral efficiency will be substantial. It is further observed substantial cell spectral efficiency loss about 54% due to UE Rx antenna reduced from four to two and DL modulation order restriction from 256QAM to 64QAM in FR1 and about 70% spectral efficiency reduction due to UE Rx antenna reduced from four to one and DL modulation order restriction from 256QAM to 64QAM in FR1 |
|  |  |  |
|  |  |  |

# Potential techniques

In this section, we summarize the proposals on potential techniques to enhance the performance for RedCap UE in various contributions under AI 8.6.3.

## UL coverage recovery

Based on the initial observation, three UL channels, PUSCH, Msg3 and PUCCH format 3 with 22 bits may be coverage limited for RedCap and need for coverage recovery. Contributions [4][9] proposed that some solutions for UL channels introduced in the Rel-17 coverage enhancement SI can be reused or tailored for RedCap UE and the enhancement of UL channel could be deprioritized in RedCap SI. One contribution [3] indicated some additional UL enhancements outside Rel-17 CE SI could also be considered considering the further loss of uplink coverage for RedCap UE due to the loss of antenna efficiency.

**Observation #1**

* The solutions for UL channels introduced in the Rel-17 CE SI could be reused for coverage recovery for RedCap UE.

**Observation #2**

* Additional UL enhancements outside Rel-17 CE SI could also be considered for RedCap
  + [1, 5, 8, 11, 13, 18, 20, 22, 23, 24] proposed frequency hopping enhancement to increase frequency diversity for RedCap UE with a reduction on the maximum channel bandwidth.
  + [3] observed that SUL can achieve 10 ~ 13 dB coverage gain and maximum cell range can be increased by 80% ~ 120%
  + [24] proposed to consider techniques to reduce the payload size for the L1 measurement report by taking advantage of the stationary conditions of the UEs in some RedCap use cases.

Based on companies’ observations, the following observations are proposed for discussion for the TP drafting for TR 38.875.

**Moderator’s observation**

* P1: The solutions for UL coverage enhancements introduced in the Rel-17 CE SI could be reused for compensating the coverage loss due to complexity reduction and the solutions includes at least
  + Cross-slot or cross-repetition channel estimation. [The potential specification impacts are phase continuity and power consistency]
  + Lower DM-RSM density in time domain. [The potential specification impacts include DM-RS pattern and configuration, power consistency and phase continuity]
  + Repetition for Msg3 initial and/or retransmission. [The potential specification impact includes signalling indication of the number of repetitions and early indication of UE capability for Msg3 repetition]
* P2: Additional UL enhancements outside Rel-17 CE SI could also be considered for RedCap including at least
  + Supplement uplink carrier
  + L1 measurement payload reduction. [The potential specification impacts include CSI reporting configuration]
  + Hopping across a larger system bandwidth. [The potential specification impact includes definition of RF retuning time and UL transmission interruption during RF retuning time.]

**Question 5.1-1: Can the above list (P1-P2) be used as a baseline text for TR 38.875? If not, what other aspects need to be added? The proponent companies are invited to provide the input for the potential specification impact and the analysis of coexistence with legacy UE.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo |  | We think the following techniques are commonly applicable for both eMBB and RedCap coverage enhancements and should be captured under the first main bullet   * + Supplement uplink carrier   + L1 measurement payload reduction. [The potential specification impacts include CSI reporting configuration]   And does L1 measurement payload reduction more related to PUCCH? However, from the representative values captured in section 3, PUCCH does not seem to require coverage recovery.  For P1, since the solutions to be study in CE SI is not clearly provided, we suggest not to capture the detailed solutions in P1. |
| ZTE |  | For RedCap UE, we don’t think SUL is a good approach considering it would increase UE supported BW and capability. In case it would be added here, please also add CA as the candidate solution for UL coverage enhancement. |
| Nokia, NSB |  | On P2, we are not sure if SUL is valid as this can depend on deployment. Also, L1 measurement payload reduction has other specification impact and may not be necessary (for PUCCH). |
| Futurewei |  | OK for existing techniques (including SUL for some deployment) + Rel 17 CE SI |
| NTT DOCOMO |  | We support to follow the solutions for UL coverage enhancements introduced in the Rel-17 CE SI, and extension of Type A and B repetitions may be one of the solutions. |
| Ericsson |  | In principle we are fine with P1.  The 2nd subbullet should be about lower “DM-RS” density.  For PUSCH data, the tradeoff between data rate and coverage can be considered. For example, HARQ retransmission and slot aggregation can be used for improving the coverage of PUSCH.  P2: no need to capture this now. |
| CATT |  | We do not think all solutions for UL coverage enhancements introduced in the Rel-17 CE SI could be reused. Considering that RedCap UE is aiming at low complexity/cost, simple methods with low implementation requirement and less specification impact are preferred. For example, we agree that repetition is recommended to Msg3 (P1 with sub-bullet1&3). |
| Samsung |  | Although likely, solutions listed in P1 are not agreed in the CE SI, it can be used “potentially introduced in the Rel-17 CE SI…”.  Not sure about SUL for RedCap and also L1 measurement payload reduction which seems related to PUCCH coverage recovery. In addition, SUL may not be mandatory for RedCap UE, and it may increase UE complexity. We should focus on the techniques can apply for most of UE with limited complexity. |
| LG |  | We are fine with main bullet in P1, but it would be better to discuss details after CE SI decision. |
| Convida Wireless |  | We agree in principle, but we have inquiry on the sub-bullet regarding Msg3 repetition. If the coverage of Msg3 needs to be compensated, the coverage of MsgA-PUSCH will require coverage enhancement as well. Please note that in AI 8.6.5, MsgA-PUSCH is one of the candidates for early UE identification. Therefore, we want to clarify whether MsgA-PUSCH should be included in the proposed baseline text for the TR or not. |
| Huawei, Hisilicon |  | We are fine with P1 and P2. For SUL, we would like to clarify that SUL does not increase UE supported BW and cost because there is no aggregated carrier bandwidth nor concurrent UL transmission between SUL carrier and NUL carrier, allowing UE hardware sharing among carriers, which is very different from CA. Additionally, in real markets, RedCap UEs will support multi bands naturally, SUL can fully utilize those UE hardware in those bands. |
| OPPO |  | Generally we are fine with the bullets in P1. Details can be further discussed according to CE SI conclusion. |
| **FL5** | Most responses seem fine with P1. However, a few responses have indicated that not all the solutions for UL coverage enhancements introduced in the Rel-17 CE SI could be reused for RedCap users and proposed to discuss details after CE SI decision.  Several responses have raised concern on the SUL and L1 measurement payload reduction since SUL is dependent on deployment and L1 measurement payload reduction is more related to PUCCH.  One response wants to clarify whether MsgA-PUSCH should be included in the proposed baseline text for the TR or not.  Based on the received response, the following updated proposals can be considered.  (FL note: for techniques that have been studied in the Rel-17 CE SI, potential specification impacts can follow the agreement in the Rel-17 CE SI and therefore not included here. **The FL intention here is to firstly summarize a list of potential techniques for coverage recovery, and the recommendation for techniques for the WI can be further discussed after drawing conclusion for coverage recovery or probably even not needed**)  **[FL5] Proposal 5.1-1A:**   * Capture the following to the TR 38.875   + Coverage recovery for PUSCH was studied from several aspects, including cross-slot or cross-repetition channel estimation, lower DM-RS density in time domain, enhancements on PUSCH repetition Type A and/or Type B, frequency hopping or BWP switching across a larger system bandwidth   + Some techniques, such as cross-slot or cross-repetition channel estimation, lower DM-RS density in time domain, enhancements on PUSCH repetition Type A and/or Type B have been studied also in the Rel-17 coverage enhancement SI   + Potential specification impacts of frequency hopping or BWP switching across a larger system bandwidth include:     - Frequency domain hopping offsets/positions     - Relaxed BWP switching time or RF retuning time     - Transmission/reception interruption during RF retuning time   **[FL5] Proposal 5.1-1B:**   * Capture the following to the TR 38.875   + Coverage recovery for Msg3 [and MsgA] was studied including repetition for Msg3 PUSCH initial and/or retransmission   + It is noted that enhancements on Msg3 PUSCH repetition have been studied also in the Rel-17 coverage enhancement SI | |
| Panasonic |  | We are generally fine with [FL5] Proposal 5.1-1A. However, we slightly prefer to highlight the recommendation of techniques or technical aspects for RedCap based on Rel-15 CE SI agreements. Otherwise, it seems there is no need to further discuss on techniques for coverage recovery for RedCap because all potential aspects can be discussed therein CE SI. |
| vivo |  | We have concern on “frequency hopping or BWP switching across a larger system bandwidth” as it clearly increases the UE complexity.  We think MSGA should not be captured as there has been no explicit evaluation/study on it. |

## PDSCH coverage recovery

**Observation #1:**

* The existing Rel-15/16 coverage enhancement techniques are sufficient in compensating for coverage loss from complexity reduction
  + [2] has observed a 1.5dB gain with the use of the lower MCS table Table 5.1.3.1-3 while achieving the target data rates for DL 2Mbps.
  + According to [12], repetition cannot improve the data rate, and instead by a lower MCS, 1-2dB gain can be achieved.

**Observation #2:**

* Further extension of the existing techniques, such as slot aggregation enhancements can be considered if larger coverage recovery is necessary
  + [5, 8, 14] proposed a larger aggregation factor, e.g. 16 or more can be used for PDSCH for RedCap UE, and extension of RRC signalling for larger aggregation factor may be needed
  + [8] also proposed to consider indicating the number of repetitions dynamically to RedCap UEs

**Observation #3:**

* Frequency domain-based solutions can be considered to increase frequency diversity for RedCap UE
  + [1, 5, 8, 11, 13, 18, 20, 22, 23, 24] indicated that hopping across a larger bandwidth is beneficial for achieving frequency diversity gain
  + [2] observed that 1-2 dB PDSCH performance loss for fixed 20MHz BW location over flexible 20MHz with a 100MHz system bandwidth and proposed to consider BWP switching in a larger system bandwidth for achieving frequency scheduling gain and load balancing.

**Observation #4:**

* Improvement on channel estimation is also useful for improving the efficiency of coverage recovery
  + [13] observed that cross-repetition channel estimation additionally can provide about 0.5-1.3dB gain over the repetition without DM-RS bundling
  + [8] indicated that the increase of the granularity of PRB bundling in channel estimation could be beneficial for a flat channel

Based on companies’ observations, the following observations are proposed for discussion for the TP drafting for TR 38.875.

**Moderator’s observation**

* P1: The existing Rel-15/16 coverage enhancement techniques (e.g. low-MCS table) are sufficient in compensating for the coverage loss from complexity reduction when the required coverage recovery is small
* P2: Further extension of the existing techniques, such as slot aggregation enhancements can be considered
  + A larger aggregation factor, e.g. 16 or more for PDSCH. The potential specification impacts are RRC signalling enhancement.
  + Dynamic indication of the number of repetitions. The potential specification impacts are DCI design for indicating the number of repetitions.
* P3: Hopping or BWP switching across a larger system bandwidth is beneficial for achieving frequency diversity gain
  + The potential specification impacts include hopping configuration for PDSCH, latency reduction for BWP switching time or RF retuning time across a larger BW
* P4: Improvement on channel estimation is also useful for improving the efficiency of coverage recovery
  + Cross-slot or cross-repetition channel estimation. The potential specification impacts include precoder cycling in time domain.
  + Increasing the granularity of PRB bundling. The potential specification impacts are new PRG size configuration.

**Question 5.2-1: Can the above list (P1-P4) be used as a baseline text for TR 38.875? If not, what other aspects need to be added? The proponent companies are invited to provide the input for the potential specification impact and the analysis of coexistence with legacy UE.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo |  | P3 requires RedCap UEs to support dynamic BWP switching with reduced delay, however, those are not assumed for reference UEs. This will definitely increase the RedCap UE complexity.  For Dynamic indication of the number of repetitions for PDSCH, it is already supported in Rel-16, such enhancements are not needed. |
| Futurewei |  | P1 is OK and may not be limited to small but may also include moderate. P2-P4 may depend on the observed CE SI. |
| Ericsson |  | We prefer to come back to this after we have a clearer view on coverage compensation needed for PDSCH. For example, P2 might not be needed if the need for PDSCH coverage compensation is not huge.  For PDSCH data, the tradeoff between data rate and coverage can be considered. (For example, HARQ retransmission and slot aggregation can be used for improving the coverage of PDSCH.) |
| CATT |  | Similar to the Question 5.1-1, simple methods with low implementation requirement and less specification impact are preferred. We think at least P1, P2 (1st bullet) are fine. |
| Samsung | Y |  |
| Convida Wireless |  | We agree in principle, but we have a question for clarification on whether PDSCH in FL’s proposals refers to PDSCH transmitted when UE is in RRC-connected mode or PDSCH transmitted when UE is in RRC-idle/inactive state, e.g. such RMSI-PDSCH and paging message. We note that there is a dedicate discussion for PDSCH of Msg2 and Msg4 in the next section. |
| OPPO | Y |  |
| **FL5** | Two responses are fine with the FL’s proposal. A few responses have suggested to further discuss after CE SI decision or having a clear view on coverage compensation needed for PDSCH. One response indicated that a tradeoff between data rate and coverage can be considered for PDSCH. One response has raised concern on P3 considering potentially UE complexity increase.  One response proposes to clarify whether PDSCH includes also PDSCH transmitted in RRC-idle and inactive states, such as such RMSI-PDSCH and paging message.  The FL’s understanding is that PDSCH for coverage evaluation is assumed with a target data rate and therefore mainly for PDSCH transmitted when UE is in RRC-connected mode. However, some enhancements are not limited to PDSCH unicast and can also be used for broadcast PDSCH. These can be further discussed during the WI phase.  Based on the received response, the following updated proposals can be considered.  (FL note: Rel-17 CE SI has not made any decision on PDSCH unicast coverage enhancement. Based on link budget analysis in section 3, coverage recovery for PDSCH unicast is needed at least for FR2 with single Rx. **The FL intention here is to firstly summarize a list of potential techniques for coverage recovery, and the recommendation for techniques for the WI can be further discussed after drawing conclusion for coverage recovery or probably even not needed**)  **[FL5] Proposal 5.2-1:**   * Capture the following to the TR 38.875   + Coverage recovery for PDSCH was studied from several aspects, including the use of the lower-MCS table, larger aggregation factor for PDSCH reception, cross-slot or cross-repetition channel estimation, increasing the granularity of PRB bundling, frequency hopping or BWP switching across a larger system bandwidth.   + Some techniques, such as the lower-MCS table and larger aggregation factor for PDSCH reception are existing techniques with optional UE capability signaling   + Potential specification impacts of cross-slot or cross-repetition channel estimation include:     - Time-domain precoder cycling and DM-RS configuration   + Potential specification impacts of frequency hopping or BWP switching across a larger system bandwidth include     - PDSCH hopping configuration     - Relaxed BWP switching time or RF retuning time     - Transmission/reception interruption during RF retuning time   + Potential specification impacts of increasing the granularity of PRB bundling include     - Related signaling design | |
| Panasonic | Y |  |
| vivo | N | Based on our understanding, the non-initial acess PDSCH coverage issue (except MSG 2 and MSG4) is only seen in FR2 indoor based on option3. However, as we commented before, we have concern on such approach to identify the coverage problem without considering the actual deployment need. |

## Msg2 and Msg4 coverage recovery

**Observation #1:**

* Slot aggregation or repetition can be used for broadcast PDSCH enhancement for RedCap UE [2, 4, 5, 23]
  + [13] showed time domain repetition by 8 transmissions for 1Rx UE can achieve the same performance as 4Rx UE at 10% BLER;
  + [25] observed a PDSCH loss of about 6dB from reducing the number of Rx antennas from 4 to 1 and it can be recovered by about 8 repetitions

**Observation #2:**

* The existing TBS scaling technique for Msg2 can achieve a coverage improvement of 3-6 dB
  + [24] also observed a restriction on Msg2 payload size with TBS scaling for RedCap UE

**Observation #3:**

* The use of lower MCS table before the RRC configuration can be used for coverage enhancement of Msg4 [2, 24]

**Observation #4:**

* The recovery schemes for PDSCH such as frequency hopping enhancement and DM-RS enhancement can be also suitable for Msg2/Msg4 [5]

Based on companies’ observations, the following observations are proposed for discussion for the TP drafting for TR 38.875.

**Moderator’s observation**

* P1: The existing TBS scaling can be used for coverage enhancement of Msg2, and slot-aggregation or repetition can be considered if a larger coverage recovery (e.g. more than 6 dB) is necessary
* P2: The use of lower MCS table before the RRC configuration can be used for coverage enhancement of channels such as Msg4, and slot-aggregation or repetition can also be considered
* P3: The recovery schemes for PDSCH such as frequency hopping enhancement and DM-RS enhancement can be also suitable for Msg2 and Msg4

**Question 5.3-1: Can the above list (P1-P3) be used as a baseline text for TR 38.875? If not, what other aspects need to be added? The proponent companies are invited to provide the input for the potential specification impact and the analysis of coexistence with legacy UE.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo |  | For P3, it is not clear how to apply the enhancements to RedCap UEs, and gNB may not fully aware of UE capability before RRC connection. |
| Futurewei |  | P2 is OK and preferable, P1 is OK as existing techniques |
| Ericsson | Y |  |
| CATT |  | We think at least P1 is fine. |
| Samsung |  | We think P1 has already been supported by Rel-15 spec. and with P1, it may not need any other enhancements for Msg 2. In addition, some analysis is needed for the evaluation results of DL channels with a big gap between companies before drawing observations. |
| Convida Wireless | Y |  |
| Huawei, Hisilicon | N | We feel that existing TBS scaling is sufficient for Msg.2, don’t see the need to consider slot-aggregation or repetition.  It should be more careful to draw a feasible conclusion on some potential enhancement for Msg4 and Msg2. Because they may be optional UE feature and gNB has no sufficient knowledge whether a UE has supported it during initial access procedure.  More investigations are needed for P1-P3. |
| OPPO | Y |  |
| **FL5** | Three responses are fine with the FL’s proposal. One response suggests having more investigation. Another three responses indicate the support for P1.  Based on the received response, the following updated proposals can be considered.  (FL note: for techniques that have been studied in the Rel-17 CE SI, potential specification impacts can follow the agreement in the Rel-17 CE SI and therefore not included here. **The FL intention here is to firstly summarize a list of potential techniques for coverage recovery, and the recommendation for techniques for the WI can be further discussed after drawing conclusion for coverage recovery or probably even not needed**)  **[FL5] Proposal 5.3-1A:**   * Capture the following to the TR 38.875   + Coverage recovery for Msg2 PDSCH was studied from several aspects, including TBS scaling and time domain repetition   + It is noted that TBS scaling is an existing technique mandatory for Rel-15 UE   + Potential specification impacts of Msg2 PDSCH repetition include     - Msg2 PDSCH repetition configuration     - Mechanism to differentiate enhanced UE and legacy UE, e.g., separate PRACH configurations (e.g, separate PRACH occasions or preambles)   **[FL5] Proposal 5.3-1B:**   * Capture the following to the TR 38.875   + Coverage recovery for Msg4 PDSCH was studied from several aspects, including early CSI on Msg3 PUSCH for early link adaptation, scaling factor for TBS determination, PDSCH repetition and the use of the lower-MCS table.   + Some techniques, such as early CSI on Msg3 PUSCH for early link adaptation, scaling factor for TBS determination and PDSCH repetition have been studied also in the Rel-17 coverage enhancement SI   + Potential specification impacts of using the lower-MCS table for Msg4 PDSCH include     - Related signaling design | |
| Panasonic | Y |  |
| vivo |  | For MSG4, we think “early CSI on Msg3 PUSCH for early link adaptation” is a scheduling efficiency improvement technique, rather than a coverage enhancement technique, we suggest to not capture it. |

## PDCCH coverage recovery

**Observation #1:**

* Repetition can compensate the coverage loss of PDCCH due to complexity reduction
  + [17] observed a loss of 8dB for AL=4 and 2Rx RedCap UE, w.r.t. AL=16 and 4Rx reference UE, and the loss was increased to more than 10dB for AL=4 and 1Rx
  + [21] indicated that with AL16 and a target PDCCH BLER of 1%, there was about 2.72dB performance loss by reducing #Rx antennas from 4 to 2, and about 6dB by reducing #Rx antennas from 4 to 1
  + [4, 24] observed that PDCCH repetition can generally provide 2 dB gain by repeating twice in time domain
  + [17, 24, 25] stated that PDCCH repetitions can be performed both within a slot and across slots.
  + [21] proposed to consider only UE-transparent PDCCH repetition scheme and UE-aware PDCCH repetition schemes are not considered for RedCap UE.
  + [12] indicated that repetition can be applied in time or frequency, effectively creating an extended CORESET

**Observation #2:**

* Compact DCI is useful for improving PDCCH coverage when the required coverage recovery is small [1, 3, 5, 8, 11, 12, 23, 26, 27]
  + [5] stated that about 1dB gain can be achieved for AL=16 at 1e-5 or 1e-6 target BLER with 10~16 bits size reduction by DCI format 0\_2/1\_2 (similar observation for target BLER 1e-2);

**Observation #3:**

* Increasing the CCE number for PDCCH transmission is another effective way to enhance PDCCH coverage [1, 4, 5, 12, 13, 17, 26]
  + [1] stated the higher aggregation level can be achieved by repetition
  + [12, 13] stated that higher aggregation level in conjunction with an extended CORESET may impact codeword generation and mapping to CCEs and may have an overall high specification impact
  + [4] indicated CORESET bundling is another scheme to increase the CCE number for PDCCH transmission. In such case, the CCE of a PDCCH is distributed across multiple CORESETs in a bundle to efficiently achieve a larger aggregation level.

**Observation #5:**

* Combination of different techniques can also be considered for PDCCH
  + [4] indicated that cross-slot channel estimation can be considered together with CORESET bundling
  + [1] proposed to consider frequency hopped CORESET for RedCap UE, and [17] proposed that frequency hopping in a wide bandwidth region can be considered for inter-slot PDCCH repetition

**Observation #6:**

* Compatibility with normal UE should be considered for broadcast PDCCH enhancement
  + [4] indicated there could be compatibility issue if RedCap and normal UEs share the same initial DL BWP
  + [19] noted it is not possible to use consecutive time resources for PDCCH repetition for CORESET0 since these resources are reserved for other SS/PBCH blocks in Rel-15/16
  + [15] stated that PDCCH coverage recovery should consider PDCCH overhead reduction and the congestion of CORESET 0 and initial BWP.

Based on companies’ observations, the following observations are proposed for discussion for the TP drafting for TR 38.875.

**Moderator’s observation**

* P1: There could be multiple candidate techniques that can be considered for coverage recovery of PDCCH, with some techniques being useful with relatively low specification impact
* P2: Dependent on the amount of coverage recovery, different solutions could be considered
  + Compact DCI is useful when the required coverage recovery is small, e.g. approximately 1dB
  + Repetition and/or increasing the CCE number for PDCCH transmission can be considered when the required coverage recovery is larger, e.g. more than 1 dB
* P3: The recovery schemes for PDCCH should consider compatibility with normal UE if RedCap and normal UEs share the same initial DL BWP

**Question 5.4-1: Can the above list (P1-P3) be used as a baseline text for TR 38.875? If not, what other aspects need to be added? The proponent companies are invited to provide the input for the potential specification impact and the analysis of coexistence with legacy UE.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo |  | Seems OK  It would be necessary to clarify that for repetition and/or increasing the CCE number for PDCCH transmission, one or more than more CORESETs may be used for PDCCH transmission. |
| Futurewei |  | Looks OK |
| Ericsson |  | P2: The meaning of “*Repetition and/or increasing the CCE number*” is not clear. Does it mean increasing the maximum supported AL in the CORESET configured for RedCap? |
| CATT |  | Generally OK. Some of the solutions may have impact on AI8.6.2 where PDCCH monitoring reduction is under discussion. May come back later. |
| Samsung | Y |  |
| LG |  | We are generally OK with P1 and P3.  Meanwhile, the meaning of candidate methods captured in sub-bullets of P2 are not clear. Also, pros and cons of various methods proposed by several companies have not been discussed in detail. So we prefer to discuss further on P2. |
| Convida Wireless |  | We agree in the principle, but we would like to clarify whether PDCCH in FL’s proposals includes RMSI-PDCCH and PDCCH that schedules Msg2/Msg4 or not. |
| Huawei, Hisilicon |  | For the perspective of coverage, it is still unclear that PDCCH enhancement is necessary.  To draw a conclusion to claim some PDCCH technique beneficial, we suggest to take into account the perspectives of network efficiency and capacity. Compact DCI can be considered to compensate the performance loss caused by UE RX antennas reduction. However, other PDCCH enhancement techniques seems not good for network efficiency and capacity, such as, repetition and/or increasing the CCE number for PDCCH transmission. Therefore, we don’t feel they are beneficial. |
| OPPO | Y | Further down-selection can be done in WI stage. |
| **FL5** | Most responses seem okay with the FL’s proposal although a few responses want to clarify and further discuss P2.  (**FL note:** **The FL intention here is to firstly summarize a list of potential techniques for coverage recovery, and the recommendation for techniques for the WI can be further discussed after drawing conclusion for coverage recovery or probably even not needed)**  Based on the received response, the following updated proposals can be considered.  **[FL5] Proposal 5.4-1:**   * Capture the following to the TR 38.875   + Coverage recovery for broadcast PDCCH (including RMSI PDCCH and PDCCH that schedules Msg2/Msg4/paging) was studied from several aspects, including PDCCH repetition, compact DCI, AL greater than 16 in conjunction with an extended CORESET, and increasing the CCE number for a PDCCH transmission via CORESET bundling   + Potential specification impacts of PDCCH repetition include     - Repetition configuration (e.g. intra-slot or inter-slot)     - DMRS design among PDCCH repetitions   + Potential specification impacts of compact DCI include     - DCI overhead reduction   + Potential specification impacts of AL greater than 16 in conjunction with an extended CORESET include     - Mechanism for codeword generation and mapping to CCEs   + Potential specification impacts of increasing the CCE number for a PDCCH transmission via CORESET bundling include     - CORESET bundling configuration     - DMRS design among CORESET bundling   + It is noted that all these techniques may have compatibility issue if RedCap and normal UEs share the same initial DL BWP | |
| Panasonic | Y |  |
| vivo | Y |  |

## SSB and PRACH coverage recovery

Two contributions [14][21] proposed a shorter SSB period of 5ms or 10ms can be considered for coverage recovery. One contribution [1] stated that the “keep trying” method can be used for improving the coverage of SSB. The contribution [12] noted that PBCH repetition design for coverage recovery must consider SSB structure for different sub-carrier spacings and different RF frequency ranges.

One contribution [1] indicated that coverage recovery for PRACH can be supported by repeating random access attempts and using longer PRACH preambles, which may not require specification enhancements.

Since majority of companies do not observe the need of coverage recovery for PRACH and SSB, the moderator’s proposal is not to capture the candidate recovery solutions for PRACH and SSB

**Question 5.5-1: Companies are invited to provide views on whether to capture the candidate recovery solutions for PRACH and SSB. The proponent companies are invited to provide the input for the potential specification impact and the analysis of coexistence with legacy UE.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo |  | From the representative values captured in section 3, there is no issue identified for SSB and PRACH. |
| Futurewei |  | No coverage recovery needed |
| Ericsson |  | No need to capture any candidate recovery solutions for PRACH and SSB. These two channels do not need coverage compensation. |
| CATT |  | No need for SSB and PRACH coverage recovery. |
| Samsung |  | We don’t see a need of coverage recovery for SSB and PRACH |
| LG |  | No need to capture the candidate solutions. |
| Huawei, Hisilicon |  | No coverage recovery needed. |
| **FL5** | No further proposal regarding coverage recovery for SSB and PRACH | |
| **vivo** | It would be useful to draw a conclusion, i.e. no coverage compensation for SSB and PRACH is needed for RedCap UEs, and capture it in the TR. | |

# References

1. R1-2008865 Coverage recovery and capacity impact for RedCap Ericsson
2. R1-2007536 Coverage recovery for RedCap FUTUREWEI
3. R1-2008813 Functionality for coverage recovery, Huawei, HiSilicon
4. R1-2007670 Discussion on coverage recovery, capacity and spectrum efficiency impact, vivo, Guangdong Genius
5. R1-2007717 Discussion on coverage recovery for RedCap UE ZTE
6. R1-2007864 Coverage recovery for reduced capability NR devices CATT
7. R1-2007889 Coverage recovery and capacity impact TCL Communication Ltd.
8. R1-2007949 On coverage recovery for RedCap UEs Intel Corporation
9. R1-2009217 Coverage Recovery and Capacity Impact Panasonic Corporation
10. R1-2008018 Discussion on coverage recovery for RedCap UEs CMCC
11. R1-2008050 Discussion on the coverage recovery of reduced capability NR devices LG Electronics
12. R1-2008070 Functionality for coverage recovery Nokia, Nokia Shanghai Bell
13. R1-2008086 Discussion on coverage recovery for reduced capability device Xiaomi
14. R1-2008102 Discussion on coverage recovery and capacity impact Spreadtrum Communications
15. R1-2008172 Coverage recovery for low capability device Samsung
16. R1-2008262 Discussion on coverage recovery issues and evaluation OPPO
17. R1-2009173 Coverage recovery for RedCap Lenovo, Motorola Mobility
18. R1-2008367 Coverage recovery for Redcap devices Sony
19. R1-2008396 Coverage recovery for reduced capability UEs Sharp
20. R1-2008472 Functionality for Coverage Recovery for RedCap Apple
21. R1-2008512 Discussion on coverage recovery for NR RedCap UEs MediaTek Inc.
22. R1-2008518 On coverage recovery for reduced capability UEs Convida Wireless
23. R1-2008553 Discussion on coverage recovery for RedCap NTT DOCOMO, INC.
24. R1-2009310 Coverage Recovery for RedCap Devices Qualcomm Incorporated
25. R1-2008686 Coverage recovery for reduced capability NR devices InterDigital, Inc.
26. R1-2008728 Discussion on Coverage Recovery for RedCap UE WILUS Inc.
27. R1-2008740 Coverage recovery for RedCap UE Sequans Communications

# Appendix –

## RAN1 agreements in 101e and 102

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| **RAN1 #101e**  Agreements: If/when coverage evaluations outside the CE SI are needed,   * The basic evaluation methodology is based on link-level simulation for FR1.   + ­Step 1: Obtain the required SINR for the physical channels under target scenarios and service/reliability requirements.   + ­Step 2: Obtain the baseline performance based on required SINR and link budget template.   + ­Note: aspects related to identifying target performance and coverage bottlenecks based on target performance metric is to be handled separately * The evaluation methodology for FR2 is the same as FR1.   Agreements: If/when link-level coverage evaluations outside the CE SI are needed,   * The CE SI link-level simulation assumptions can be used as a starting point. * For calibration purposes, the following settings can be used:  |  |  |  | | --- | --- | --- | | **Parameters** | **FR1 values** | **FR2 values** | | Scenario and frequency | Urban:  2.6 GHz (TDD) (primary choice)  4 GHz (TDD) (secondary choice)  Rural:  700 MHz (FDD) | Indoor: 28 GHz (TDD) | | Frame structure for TDD | For 2.6 GHz:  DDDDDDDSUU  (S: 6D:4G:4U)  For 4 GHz:  DDDSUDDSUU  (S: 10D:2G:2U) | DDDSU  (S: 10D:2G:2U) | | Channel model | TDL-C | TDL-A | | UE velocity | 3 km/h | 3 km/h | |  |  |  |   **RAN1 #102 e:**  Agreements: For the channel(s) affected by complexity reduction, the following methodology can be used to determine the target performance for coverage recovery.   * Step 1: Obtain the link budget performance of the channel based on link budget evaluation * Step 2: Obtain the target performance requirement for RedCap UEs within a deployment scenario * FFS on the target performance requirement * Step 3: Find the coverage recovery value for the channel if the link budget performance is worse than the target performance requirement   Agreements: Link budget evaluation for RedCap should include at least PDCCH/PDSCH and PUCCH/PUSCH.  Agreements: For initial access related channels, at least Msg2, Msg3, Msg4 and PDCCH scheduling Msg2/4 are included for link budget evaluation   * Other initial access related channels are not precluded   Agreements: The impact of small form factor is considered for all the uplink and downlink channels   * A 3dB loss of antenna gain is included in link budget calculation for FR1   + - FFS on the application to both FDD and TDD bands or only FDD bands [revised, see below]   Agreements: For link budget evaluation, the antenna gain loss due to the small form factor can be applied to all the FR1 bands   * For RedCap coverage analysis, the agreements in the Rel-17 CE SI regarding link budget template and antenna array gain are reused.   + Continue to discuss and decide the performance metric in RAN1-103 e-meeting   Agreements: Down-selection on the following options for the target performance requirement for RedCap UEs in RAN1#103-e (aim for early in the e-meeting):   * Option 1: The target performance requirement for each channel is identified by a target MCL or MIL or MPL within a reasonable deployment * Option 3: The target performance requirement for each channel is identified by the link budget of the bottleneck channel(s) for the reference NR UE within the same deployment scenario   + Note: The “bottleneck channel(s)” are the physical channel(s) that have the lowest MCL or MIL or MPL * The details for the target performance requirement are FFS   Agreements: For RedCap UE, adopt the following target data rates for link budget evaluation for FR1 Rural.   * 1 Mbps on DL and 100kbps in UL   Agreements: For RedCap UE, adopt the following target data rates for link budget evaluation for FR1 Urban.   * 2 Mbps on DL and 1Mbps in UL   Note: The 2Mbps target data rate in downlink is the scaled value of the 10Mbps in the CE SI by a factor of 0.2  Agreements:  For RedCap UEs, the target data rates for link budget evaluation for FR2 are as follows:   * 25Mbps for BW 50MHz/100MHz on DL and 5Mbps in UL   + Optionally, 12.5Mbps for BW 50MHz as the target data rate for DL, assuming the same DL PSD as that of BW 100MHz   + Note: in case of 50MHz BW, the maximum supported DL data rate is half that of the 100MHz BW in DL   Agreements: For RedCap coverage evaluation, the Rel-17 CE SI agreements on gNB antenna configuration, # gNB Tx/Rx chains, channel model and delay spread are reused with the following revision and/or addition   |  |  |  | | --- | --- | --- | | **Parameters** | **FR1 values** | **FR2 values** | | Channel model | TDL-C | TDL-A  CDL-A(optional) | | Delay spread | 300ns | 30ns | | UE velocity | 3 km/h | 3 km/h | | Antenna correlation | Low | Low | | # gNB Tx chains | 2 or 4 | 2 | | # gNB Rx chains | 2 or 4 | 2 |   For RedCap coverage evaluation, adopt the following table for the reference NR UE.   |  |  |  | | --- | --- | --- | | **Parameters** | **FR1 values** | **FR2 values** | | # UE Tx chains | 1 | 1 | | # UE Rx chains | Urban: 4 and Rural: 2 | 2 | | UE BW | Urban: 100 MHz (273 PRBs)  Rural: 20 MHz (106 PRBs) | 100 MHz (66 PRBs) |   For RedCap coverage evaluation, adopt the following table for the RedCap UE.   * + Other UE BWs are not precluded  |  |  |  | | --- | --- | --- | | **Parameters** | **FR1 values** | **FR2 values** | | # UE Tx chains | 1 | 1 | | # UE Rx chains | 1 or 2 | 1 or 2 | | UE BW | Urban: 20 MHz (51 PRBs)  Rural: 20 MHz (106 PRBs) | 50 MHz (32 PRBs) or  100 MHz (66 PRBs) |   Agreements: For RedCap coverage evaluation, reuse the Rel-17 CE SI agreements on channel specific parameters with the following revision and/or addition   * + TBS/PRB/MCS of PDSCH (except for Msg2)/PUSCH for the RedCap UE are based on the agreed target data rates or message sizes and reported by companies   + Adopt the following table for Msg2 evaluation     - Note: the TBS scaling is not precluded in the table entry “PRBs/TBS/MCS”  |  |  | | --- | --- | | **Parameters** | **Values** | | PRBs/TBS/MCS | MCS is fixed to zero. Companies to report the used number of PRBs and corresponding TBS value | | PDSCH duration | 12 OS | | DMRS configuration | Type I, 3 DMRS symbol, no multiplexing with data | | Waveform | CP-OFDM | | HARQ configuration | No retransmission |   Agreements:   * For SLS based capacity evaluation, use the assumption in TR 38.802, Table A.2.1-1 as the baseline. * For calibration purposes, the following settings can be used:  |  |  |  | | --- | --- | --- | | **Parameters** | **FR1 values** | **FR2 values** | | Layout | Single layer Macro layer: Hex. Grid | Single layer  Indoor floor: (12BSs per 120m x 50m)  Candidate TRP numbers: 3, 6, 12 | | Inter-BS distance | 500m | 20m | | Scenario and frequency | Dense Urban:  2.6 GHz (TDD) (primary choice)  4 GHz (TDD) (secondary choice)  Other scenarios (e.g. Rural 700MHz) are not precluded. | Indoor: 28 GHz (TDD) | | Frame structure for TDD | For 2.6 GHz:  DDDDDDDSUU (S: 6D:4G:4U)  For 4 GHz:  DDDSUDDSUU (S: 10D:2G:2U) | DDDSU (S: 10D:2G:2U) | | Channel model | 3Duma | 5GCM office | | UE distribution | 20% Outdoor in cars: 30km/h, 80% Indoor in houses: 3km/h | 100% Indoor: 3km/h | | Traffic model | Full buffer (Optional)  Non-full buffer traffic, e.g. FTP traffic model 3 for the reference NR UEs and the IM traffic model from TR 38.840 for RedCap UEs | | | Traffic load | Full buffer traffic (Optional):  10 users per cell including both RedCap and reference NR UEs  Non-full buffer traffic:  Low (e.g. <30%) and medium (e.g. 30%-50%) loading (resource utilization) | | | Percentage of RedCap UEs among total number of UEs  Note: Other UEs are the reference NR UEs | Full buffer traffic (Optional):  0, 20%, 50% (i.e. 0, 2 or 5 RedCap UEs per cell), 100% (as applicable)  Non-full buffer traffic:  0, 25%, 50%, 100% (optional, as applicable) | | |

## RAN1 agreements in 103e

Agreements**:**

* If coverage recovery target ~~performance requirement~~ is based on Option 1
  + Maximum pathloss loss (MPL) is used as the coverage evaluation metric
* If coverage recovery target ~~performance requirement~~ is based on Option 3
  + Maximum isotropic loss (MIL) is used as the coverage evaluation metric

Agreements:

* For Option 3, down-selection on the following alternatives for coverage recovery
  + Alt 1: A single coverage recovery target based on the same bottleneck channel is used for initial access channels and non-initial access channels of RedCap UE
  + Alt 2: Identify 2 coverage recovery targets for the RedCap UE initial access channels and non-initial access channels, respectively:
  + The 1st target is based on the bottleneck channel among the initial access channels of the reference NR UE
  + The 2nd target is based on the bottleneck channel among all the channels of the reference NR UE
  + Note: The initial access channels include at least PBCH, PRACH, Msg2, Msg3, Msg4 and PDCCH CSS

Agreements:

* Agree in principle using Option 3 for determining the coverage recovery target
  + Option 3: The coverage recovery target for each channel of RedCap UE corresponds to the link budget of the bottleneck channel(s) for the reference NR UE within the same deployment scenario
  + Note: The reference UE is a Rel-15/16 NR UE with mandatory features only
* FFS For Option 3, companies report their individual observations of the amount of compensation for each channel by comparing the link budget with that of the bottleneck channel for the reference NR UE (i.e. the LB of the channel for RedCap UE – the LB of the bottleneck channel for the reference UE)
  + A representative value of the amount of compensation is derived by taking the mean value (in dB domain) from all the compensation values including both negative and non-negative values
    - Excluding the highest & the lowest values when the number of samples is more than 3
    - If the number of samples used to compute a representative value is less than 4 for each scenario, this representative value is not used for bottleneck identification
    - In this case, observations may still be drawn
  + The representative value of a channel is used for identifying whether the channel needs coverage recovery
    - Coverage recovery is not needed if the representative value of a channel is larger than or equal to zero