**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 #3 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 |

# Target Performance Requirements

**Open issue #1 is to define the target performance for coverage recovery.**

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| **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 |

According to the contributions submitted to this meeting, the companies’ views are summarized as follows:

* 6 companies support Option 1
  + Huawei, vivo, Xiaomi, Qualcomm, Apple, Panasonic [if the reasonable scenario can be agreeable]
* 11 companies support Option 3
  + Ericsson, ZTE, [Futurewei], CATT, Intel, LG, Nokia, Spreadtrum, Samsung, MediaTek, DOCOMO

For Option 1, the proponents also make the following proposals:

* The reasonable deployment can be typical scenario as defined in TR 38.913, for which the reference UE can work effectively with the satisfaction of ITU requirements [4].
* Target performance can be defined as the required MPL at the distance of being from the base station for hexagonal cells [3].

The concerns on Option 1 from the opponents are captured below.

* It is not clear how a reasonable deployment is defined in the RedCap coverage study [1]
* There is no agreement on the specific values for the parameters related to MPL and it would be difficult to align on the MPL calculation and get a suitable absolute target MPL value for Option 1 [5]
* May introduce unnecessary coverage optimizations for the RedCap UE [15]

Additionally, [1] and [5] have proposed to further enhance the target value of Option 2 to close the performance gap between RedCap and Rel-17 NR coverage enhancement UEs

* Consider the channel with the second-lowest MIL (MCL or MPL) as the bottleneck channel [1]
* Add an additional margin on top of the target value determined by the link budget calculation for Rel-15/16 UE [5]

From moderator perspective, more input is needed from companies to decide for Option 1.

* Whether the typical scenarios (i.e. Urban macro ISD 500m, Rural ISD 1732m, indoor ISD 20m) defined in TR 38.913 can be used as the reasonable deployment for determining the target performance
* Whether the target performance can be defined as the required MPL at the distance of being from the base station for hexagonal cells
* The values of the parameters related to MPL. Note the Rel-17 CE SI has concluded in RAN1#102-e that RAN1 will not further discuss on specific values for the parameters related to MPL.

For Option 3, the main concern is the coverage problem for Redcap UEs in Rel-17 network if the a Rel-15/16 NR UE is chosen as the reference NR UE. Also, due to different assumptions on antenna gains for link budget calculation, the variance of the bottleneck channel link budget performance by companies can be very large and it would be difficult to derive a representative value as the target performance.

From moderator perspective, for Option 3, the main focus is to identify the performance loss of RedCap UE relative to the reference NR UE and it is not necessary to define an absolute target performance. Therefore, based on Option 3, we could have company specific target performance and use it to identify the coverage limiting channels for RedCap UE and the amount of compensation.

**Open issue #2: Select the performance metric from MIL, MCL, and MPL for coverage recovery analysis.**

The contribution [3] indicates MPL is more suitable than MIL or MCL for Option 1, and [5] proposes MIL is used as the performance metric for coverage bottleneck(s) identification. From moderator perspective, the selection is highly based on how the coverage recovery target is determined.

**Moderator’s proposals for 10/29 GTW:**

**Proposal #1**

* Agree in principle using Option 3 for determining the coverage recovery target
  + Option 3: The coverage recovery target ~~performance requirement~~ for each channel of RedCap UE corresponds to ~~is identified by~~ the link budget of the bottleneck channel~~(s)~~ for the reference NR UE ~~within the same deployment scenario~~
  + For Option 3, coverage recovery is not considered for a channel if the link budget for the channel exceeds that of the bottleneck channel for the reference NR UE
  + Further discussion whether Option 1 can be additional criteria for identifying the channels for coverage recovery (aim for early next week)
* For each scenario, companies report their individual observations of the bottleneck channel for the reference NR UE based on individual evaluation results and use the corresponding link budget to derive the channels to compensate and the amount of compensation
  + A channel is considered for coverage recovery if the number of observations that need for compensation is more than X. FFS the value of X
  + A representative value of the amount of compensation is derived by taking the mean value (in dB domain) from all the compensation values from the observations that need for compensation

**Proposal #2**

* 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

**Updated proposal #1 based on discussion on 10/29 GTW**

* 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
  + Further discussion whether Option 1 can be additional criteria for identifying the channels for coverage recovery
* 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 ~~from the observations that need for compensation~~
  + 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
  + Details are FFS (e.g. coverage recovery is not needed if the representative value of a channel is larger than zero)

Question 2-1: Companies are invited to input views for the above moderator’s updated proposal.

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| **Company** | **Comments** |
| Futurewei | In general we think a representative value is the way to go with removing the outliers to avoid having to compensate to channel that may not need compensation. Handling it similar to what is being done in CE should be OK |
| vivo | 1. Based on the last GTW session, using Option 3 alone as the metric to decide the need for coverage recovery have several issues, so we would like to see progress of option 1 as well. Can FL provide an proposal for option 1 as well? 2. We see in the following sections there are cases that quite some companies reported the need for coverage recovery for a given channel but the representative value is larger than zero, how to handle these cases? |
| ZTE | Given the compensation is calculated by ‘the LB of the channel for RedCap UE – the LB of the bottleneck channel for the reference UE’ and we only have the LB for Rel-15/16 UE as the baseline performance, is it a common understanding that the reference UE here is Rel-15/16 UE?  For the FFS in the last bullet, it seems we need to also include the case with the representative value equal to zero. |
| Spreadtrum | It seems that according to Option 3 the channels identified to be coverage recovered are also addressed in CE topic, e.g. PUSCH, Msg2/3/4. It is reasonable since the additional coverage compensation should be applied for these channels. But we still think the coverage loss due to RX reduction should also be compensation according to Option 1.  Currently, the evaluation methodology has just one set of assumptions (e.g. MCS, TBS) for LLS for each channel, which could be for the typical case but not for the worst case. We believe there is marginal link budget for the DL channel for the NR reference UE leaving for the worst case, but the marginal link budget is gone for the DL channel for the RedCap UE. We suspect the user experience in real world deployment, if the marginal linke budget is gone for the DL channel for the RedCap UE.  If there is no need for coverage compensation for the RX reduction, it is still strange for us. Does it mean the normal UE can turn off some of RX for power saving purpose autonomously? |
| Qualcomm | As commented earlier, the proposal may not solve the initial access being worse than “Ref” issue. For example, if the bottleneck channel is PUSCH or PDSCH, then the initial access channels for the RedCap UE may still be better than the bottleneck ref channel but worse that the initial access channels of the ref UE. Thus, per the proposal, they will not be considered for recovery. Hence, RedCap UE will have worse coverage (for initial access) compared to Ref UE. Even if some recovery is done for initial access, it may not be enough to close the gap compared to Ref UE. We think this is a problem. Taking into consideration that UL (or DL) data rates were just semi-arbitrary (i.e., if different rates were chosen different recovery would be needed), we don’t fully agree with the proposal.  We propose the following to fix this issue: apply option 3 separately to initial access channels and to other channels (e.g., unicast channels), i.e., come up with 2 coverage recovery targets for the channels of RedCap UEs where the first target is based on the bottleneck channel among all the channels of the reference UE and the second target is based on the bottleneck channel among the initial access channels (PRACH, msg2, msg3, msg4, PDCCH CSS) of the reference NR UE.  The first and second target are used to calculate the coverage recovery needed for the RedCap UE unicast and initial access channels, respectively.  Therefore, we propose the following revision to the proposal #1.   * 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   + Further discussion whether Option 1 can be additional criteria for identifying the channels for coverage recovery   + A second coverage recovery target is used for calculating the coverage recovery needed for the RedCap UE initial access channels (PRACH, msg2, msg3, msg4 and PDCCH CSS) and the second coverage recovery target is based on the bottleneck channels among the initial access channels of the reference NR UE |
| Nokia, NSB | We are fine with the FL’s proposal. Our understanding is that reference UE is the Rel-15/16 UE. With respect to Qualcomm’s point, if the initial access channels for the RedCap UE are better than of the bottleneck channel, we don’t see the need to close the gap with the initial access channels for the reference UE. |
| Futurewei | In general we think a representative value is the way to go with removing the outliers to avoid having to compensate to channel that may not need compensation. Handling it similar to what is being done in CE should be OK. Agree with Nokia in sense no need to change definition of Option 3. |
| NTT DOCOMO | We are fine with the FL proposal. |
| Apple | We would like to echo the coverage observation and concerns on initial access channels raised by Qualcomm for Opt.3. In real network, it was observed in the test field that normal NR devices can successfully access the network through the RA procedure. However, it is failed for wearable devices due to the RA related channels coverage loss caused by smaller form factor and lower antenna efficiency. Note that for this failure case, the coverage performance of channels in RA procedure for wearable devices is still better than that of the PUSCH with certain target data rate.  To address this potential problem for Redcap devices e.g. wearable devices, it is important to target to the coverage of RA channels of normal NR devices due to fundamentally different functions of these channels. |

# Coverage Recovery

On RAN1#102e meeting, it was agreed to take the following steps to identify the channels which need coverage recovery and the corresponding coverage-recovery values. In the following subsections, we summarize the link budget analysis based on companies’ evaluation results.

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

## 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) | 168.5 | 168.5 | 166.6 |  |  |  | 160.6 |  | 156.4 | 144.9 |  |  | 144.9 |
| Margin (dB) | 23.5 | 23.5 | 21.7 |  |  |  | 15.7 |  | 11.4 | 0.0 |  |  |  |
| 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) | 162.8 | 162.8 | 161.0 |  |  |  | 157.1 |  | 152.8 | 141.9 |  |  | 144.9 |
| Margin (dB) | 17.8 | 17.8 | 16.0 |  |  |  | 12.2 |  | 7.9 | -3.0 |  |  |  |
| 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) | 159.6 | 159.6 | 158.0 |  |  |  | 157.1 |  | 152.8 | 141.9 |  |  | 144.9 |
| Margin (dB) | 14.6 | 14.6 | 13.1 |  |  |  | 12.2 |  | 7.9 | -3.0 |  |  |  |
| 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 |  |

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** |

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| --- | --- | --- | --- | --- |
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|  |  |  |  |  |
|  |  |  |  |

**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. |

Based on the results in Table 3.1-4, 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 3.1-4]

**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. |

## 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 | 162.5 |  |  |  | 155.8 |  | 150.8 | 146.7 |  |  | 146.7 |
| Margin (dB) | 14.5 | 14.5 | 15.8 |  |  |  | 9.1 |  | 4.1 | 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 | 159.5 |  |  |  | 152.8 |  | 147.8 | 143.7 |  |  | 146.7 |
| Margin (dB) | 11.5 | 11.5 | 12.8 |  |  |  | 6.1 |  | 1.1 | -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 | 156.6 |  |  |  | 152.8 |  | 147.8 | 143.7 |  |  | 146.7 |
| Margin (dB) | 7.7 | 7.7 | 9.9 |  |  |  | 6.1 |  | 1.1 | -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 |  |

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. |

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 |
|  |  |  |

## 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) | 159.5 | 159.5 | 157.6 |  |  |  | 160.6 |  | 156.6 | 144.9 |  |  | 144.9 |
| Margin (dB) | 14.5 | 14.5 | 12.7 | -144.9 | -144.9 |  | 15.7 | -144.9 | 11.6 | 0.0 | -144.9 |  |  |
| 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 |  |

**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) | 153.8 | 153.8 | 152.0 |  |  |  | 157.1 |  | 152.8 | 141.9 |  |  | 144.9 |
| Margin (dB) | 8.8 | 8.8 | 7.0 |  |  |  | 12.2 |  | 7.9 | -3.0 |  |  |  |
| 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) | 150.6 | 150.6 | 149.0 |  |  |  | 157.1 |  | 152.8 | 141.9 |  |  | 144.9 |
| Margin (dB) | 5.6 | 5.6 | 4.1 |  |  |  | 12.2 |  | 7.9 | -3.0 |  |  |  |
| 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 |  |  |

**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 |  |

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. |

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 |
|  |  |  |

## 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 | 142.4 |  |  |  | 166.3 |  | 160.7 | 143.4 |  |  | 142.4 |
| Margin (dB) | 4.8 | 4.8 | 0.0 |  |  |  | 23.9 |  | 18.2 | 0.9 |  |  |  |
| 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 | 138.4 | 140.5 | 137.6 | 142.3 | 157.0 | 157.3 | 154.2 | 137.4 | 150.9 | 150.9 | 137.4 |
| Margin (dB) | 1.8 | 2.6 | 1.1 | 3.1 | 0.2 | 4.9 | 19.6 | 19.9 | 16.8 | 0.0 | 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 |  | 143.3 | 160.3 |  | 142.0 |
| Margin (dB) | 2.9 | 2.9 | -3.5 | -4.8 | -5.0 |  | 16.6 | 22.0 |  | 1.4 | 18.3 |  |  |
| Ericsson | MIL (dB) | 128.2 | 129.2 | 124.4 | 122.4 | 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 | -5.6 | -4.5 | 2.6 | 22.5 | 22.6 | 20.1 | 10.7 | 18.3 | 21.1 |  |
| InterDigital | MIL (dB) | 143.5 | 143.5 | 138.3 |  |  |  | 166.3 |  | 160.7 | 143.4 |  |  | 142.4 |
| Margin (dB) | 1.0 | 1.0 | -4.1 |  |  |  | 23.9 |  | 18.2 | 0.9 |  |  |  |
| 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 | 137.4 |
| Margin (dB) | -2.3 | -1.5 | -9.4 | -0.3 | -3.4 | 0.4 | 19.6 | 19.9 | 16.8 | 0.0 | 13.5 | 13.5 |  |

**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 | 139.5 | 137.2 |  | 157.5 | 153.9 | 150.4 | 133.3 | 149.4 |  | 133.3 |
| Margin (dB) | 12.7 | 12.6 | 3.7 | 6.2 | 3.9 |  | 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 | 137.1 | 137.0 |  | 158.6 | 164.0 |  | 145.9 | 160.3 |  | 142.0 |
| Margin (dB) | 2.9 | 2.9 | -4.6 | -4.8 | -5.0 |  | 16.6 | 22.0 |  | 4.0 | 18.3 |  |  |
| Ericsson | MIL (dB) | 130.2 | 131.2 | 124.8 | 122.4 | 123.5 | 134.3 | 150.5 | 150.5 | 148.1 | 143.6 | 146.3 | 149.1 | 128.0 |
| Margin (dB) | 2.2 | 3.2 | -3.2 | -5.6 | -4.5 | 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 | 122.4 | 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 | -5.6 | -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 |  |

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 |
| 2Rx 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. |

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 |
|  |  |  |
|  |  |  |

# Capacity impact

Based on the latest available evaluation results in [RedCapCapacity-v008-QC-Nokia](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/drafts/8.6/EvaluationResults/RedCapCapacity/RedCapCapacity-v008-QC-Nokia.xlsx), the SLS evaluation of complexity reduction to network capacity are summarized in Table 3.2-1 to Table 3.2-3 (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 | eMBB UE | 631.00 | 631.00 | 637.00 | \ | 315.00 | 312.00 | 321.00 | \ | 6.30 |  |  | \ |
| Redap UE | \ | 85.00 | 87.00 | 85.00 | \ | 37.00 | 38.00 | 38.00 | \ |  |  | 4.20 |
| All UEs | 631.00 | 628.00 | 632.00 | 85.00 | 315.00 | 301.00 | 274.00 | 38.00 | 6.30 | 6.20 | 6.20 | 4.20 |
| Huawei | eMBB UE | 86.96 | 58.82 | 39.22 | \ | 33.33 | 21.98 | 16.95 | \ | 5.76 | 5.68 | 4.87 | \ |
| Redap 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 | eMBB UE | 464.86 | 470.23 | 465.56 |  | 164.03 | 162.74 | 164.62 |  | 5.47 | 5.49 | 5.49 |  |
| Redap 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 | eMBB UE | 365.00 |  |  | \ | 176.00 |  |  | \ | 6.15 |  |  | \ |
| Redap UE | \ |  |  | 30.00 | \ |  |  | 1.00 | \ |  |  | 3.47 |
| All UEs | 365.00 |  |  | 30.00 | 176.00 |  |  | 1.00 | 6.15 |  |  | 3.47 |
| Qualcomm | eMBB UE | 168.12 | 176.74 | 204.66 | \ | 57.05 | 67.20 | 87.43 | \ | 8.98 | 9.22 | 9.70 | \ |
| Redap 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 | eMBB UE | 566.84 | 559.97 | 559.85 | \ | 311.07 | 307.67 | 310.84 | \ | 8.04 | 8.04 | 8.04 | \ |
| Redap UE | \ | 52.11 | 52.06 | 52.05 | \ | 19.82 | 19.81 | 18.97 | \ | 3.00 | 3.00 | 3.00 |
| All UEs | 566.84 | 500.17 | 109.55 | 52.05 | 311.07 | 34.45 | 26.81 | 18.97 | 8.04 | 6.78 | 5.52 | 3.00 |

**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 | 629.00 | 632.00 | 634.00 | \ | 313.00 | 313.00 | 317.00 | \ | 6.30 |  |  | \ |
| Redap UE | \ | 63.00 | 63.00 | 62.00 | \ | 29.00 | 28.00 | 28.00 | \ |  |  | 2.90 |
| All UEs | 629.00 | 631.00 | 630.00 | 62.00 | 313.00 | 302.00 | 275.00 | 28.00 | 6.30 | 6.20 | 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 | \ |
| Redap 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 |  |
| Redap 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 |  |  | \ |
| Redap 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 | \ |
| Redap 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 | 566.84 | 559.97 | 559.85 | \ | 311.07 | 307.67 | 310.84 | \ | 8.04 | 8.04 | 8.04 | \ |
| Redap UE | \ | 42.34 | 41.51 | 41.51 | \ | 14.41 | 14.47 | 14.73 | \ | 2.15 | 2.15 | 2.15 |
| All UEs | 566.84 | 500.16 | 109.57 | 41.51 | 311.07 | 23.32 | 18.24 | 14.73 | 8.04 | 6.57 | 5.09 | 2.15 |

**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 | eMBB UE | 505.00 | 511.00 | 513.00 | \ | 217.00 | 232.00 | 234.00 | \ | 6.00 |  |  | \ |
| Redap UE | \ | 66.00 | 67.00 | 65.00 | \ | 28.00 | 28.00 | 28.00 | \ |  |  | 3.80 |
| All UEs | 505.00 | 509.00 | 506.00 | 65.00 | 217.00 | 224.00 | 203.00 | 28.00 | 6.00 | 6.00 | 5.80 | 3.80 |
| Huawei | eMBB UE | 64.52 | 41.67 | 28.57 | \ | 20.10 | 12.20 | 8.70 | \ | 5.33 | 5.45 | 4.90 | \ |
| Redap 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 | eMBB UE | 388.54 | 392.09 | 397.28 |  | 97.68 | 94.44 | 97.61 |  | 5.13 | 5.09 | 5.14 |  |
| Redap 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 | eMBB UE | 258.00 |  |  | \ | 90.00 |  |  | \ | 5.80 |  |  | \ |
| Redap UE | \ |  |  | 18.00 | \ |  |  | 0.50 | \ |  |  | 2.40 |
| All UEs | 258.00 |  |  | 18.00 | 90.00 |  |  | 0.50 | 5.80 |  |  | 2.40 |
| Qualcomm | eMBB UE | 139.30 | 152.74 | 187.06 | \ | 51.80 | 61.85 | 84.05 | \ | 7.99 | 8.26 | 9.09 | \ |
| Redap 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 | eMBB UE | 448.77 | 449.90 | 443.48 | \ | 221.27 | 222.01 | 221.40 | \ | 6.64 | 6.64 | 6.64 | \ |
| Redap UE | \ | 21.52 | 22.15 | 22.28 | \ | 3.94 | 3.83 | 3.83 | \ | 1.65 | 1.65 | 1.65 |
| All UEs | 448.77 | 375.86 | 115.45 | 22.28 | 221.27 | 9.80 | 5.56 | 3.83 | 6.64 | 5.39 | 4.14 | 1.65 |

**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 | 504.00 | 514.00 | 521.00 | \ | 218.00 | 234.00 | 233.00 | \ | 6.00 |  |  | \ |
| Redap UE | \ | 53.00 | 53.00 | 52.00 | \ | 21.00 | 20.00 | 19.00 | \ |  |  | 2.60 |
| All UEs | 504.00 | 513.00 | 514.00 | 52.00 | 218.00 | 225.00 | 201.00 | 19.00 | 6.00 | 5.90 | 5.60 | 2.60 |
| Huawei | eMBB UE | 64.52 | 27.78 | 18.18 | \ | 20.10 | 7.25 | 4.52 | \ | 5.33 | 5.25 | 5.23 | \ |
| Redap 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 |  |
| Redap 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 |  |  | \ |
| Redap 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 | \ |
| Redap 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 | 448.77 | 449.90 | 443.48 | \ | 221.27 | 222.01 | 221.40 | \ | 6.64 | 6.64 | 6.64 | \ |
| Redap UE | \ | 18.93 | 19.94 | 20.11 | \ | 3.88 | 3.88 | 3.81 | \ | 1.48 | 1.48 | 1.48 |
| All UEs | 448.77 | 375.87 | 115.45 | 20.11 | 221.27 | 7.72 | 5.16 | 3.81 | 6.64 | 5.35 | 4.06 | 1.48 |

**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 | \ | 0.400 |  |  | \ |
| Redap UE | \ | 12.000 | 12.000 | 11.000 | \ | 2.700 | 2.700 | 2.200 | \ |  |  | 0.400 |
| All UEs | 47.000 | 46.000 | 46.000 | 11.000 | 3.000 | 3.000 | 3.000 | 2.200 | 0.400 | 0.400 | 0.400 | 0.400 |
| Huawei | eMBB UE | 8.420 |  | 3.430 | \ | 0.220 |  | 0.220 | \ | 1.660 |  | 1.650 | \ |
| Redap UE | \ |  | 1.940 | 4.300 | \ |  | 0.210 | 0.230 | \ |  | 0.840 | 0.820 |
| All UEs | 8.420 |  | 2.880 | 4.300 | 0.220 |  | 0.220 | 0.230 | 1.660 |  | 1.160 | 0.820 |
| vivo | eMBB UE | 21.400 | 22.811 | 23.444 |  | 0.063 | 0.061 | 0.059 |  | 1.008 | 1.008 | 1.006 |  |
| Redap UE | \ | 0.556 | 0.473 |  | \ | 0.070 | 0.004 |  | \ | 0.245 | 0.245 |  |
| All UEs | 21.400 | 8.695 | 4.489 |  | 0.063 | 0.062 | 0.058 |  | 1.008 | 0.962 | 0.879 |  |
| Nokia | eMBB UE | 7.07 | 7.180 | 7.191 | \ | 2.34 | 2.379 | 2.361 | \ | 2.42 | 2.418 | 2.418 | \ |
| Redap UE | \ | 5.544 | 5.225 | 5.13 | \ | 1.319 | 1.287 | 1.28 | \ | 1.947 | 1.947 | 1.95 |
| All UEs | 7.07 | 6.75 | 6.18 | 5.13 | 2.34 | 2.06 | 1.67 | 1.28 | 2.42 | 2.30 | 2.18 | 1.95 |

**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 | 39.000 | 39.000 | 39.000 | \ | 1.900 | 1.900 | 1.900 | \ | 0.400 |  |  | \ |
| Redap UE | \ | 11.000 | 11.000 | 11.000 | \ | 1.800 | 1.800 | 1.100 | \ |  |  | 0.500 |
| All UEs | 39.000 | 38.000 | 38.000 | 11.000 | 1.900 | 1.900 | 1.900 | 1.100 | 0.400 | 0.400 | 0.400 | 0.500 |
| Huawei | eMBB UE | 7.340 | 5.230 | 3.400 | \ | 0.220 | 0.220 | 0.230 | \ | 2.040 | 2.200 | 2.220 | \ |
| Redap UE | \ | 2.470 | 2.010 | 3.600 | \ | 0.190 | 0.220 | 0.240 | \ | 0.730 | 0.970 | 1.340 |
| All UEs | 7.340 | 4.410 | 2.900 | 3.600 | 0.220 | 0.200 | 0.220 | 0.240 | 2.040 | 1.820 | 1.590 | 1.340 |
| vivo | eMBB UE | 19.929 | 19.877 | 18.060 |  | 0.065 | 0.064 | 0.061 |  | 1.011 | 1.007 | 1.012 |  |
| Redap UE | \ | 0.328 | 0.398 |  | \ | 0.034 | 0.032 |  | \ | 0.248 | 0.245 |  |
| All UEs | 19.929 | 14.120 | 2.791 |  | 0.065 | 0.062 | 0.056 |  | 1.011 | 0.963 | 0.898 |  |
| Nokia | eMBB UE | 4.77 | 4.831 | 4.830 | \ | 1.14 | 1.134 | 1.135 | \ | 2.38 | 2.383 | 2.383 | \ |
| Redap UE | \ | 3.418 | 3.295 | 3.18 | \ | 0.544 | 0.544 | 0.57 | \ | 1.950 | 1.950 | 1.95 |
| All UEs | 4.77 | 4.37 | 3.91 | 3.18 | 1.14 | 0.95 | 0.79 | 0.57 | 2.38 | 2.27 | 2.17 | 1.95 |

**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 | 473.00 | 476.00 | 502.00 | \ | 49.00 | 35.00 | 84.00 | \ | 3.00 |  |  | \ |
| Redap UE | \ | 63.00 | 65.00 | 66.00 | \ | 0.90 | 16.00 | 16.00 | \ |  |  | 1.90 |
| All UEs | 473.00 | 472.00 | 494.00 | 66.00 | 49.00 | 32.00 | 74.00 | 16.00 | 3.00 | 3.00 | 2.80 | 1.90 |
| Huawei | eMBB UE | 62.50 | 41.17 | 27.56 | \ | 19.05 | 12.09 | 9.63 | \ | 5.02 | 4.95 | 4.63 | \ |
| Redap 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 |  |
| Redap 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 | \ |
| Redap 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 | 489.57 | 489.57 | 489.55 | \ | 258.02 | 260.46 | 267.85 | \ | 7.86 | 7.86 | 7.86 | \ |
| Redap UE | \ | 44.28 | 44.76 | 44.36 | \ | 15.36 | 17.94 | 16.79 | \ | 2.96 | 2.96 | 2.96 |
| All UEs | 489.57 | 431.70 | 140.30 | 44.36 | 258.02 | 28.25 | 23.15 | 16.79 | 7.86 | 6.63 | 5.41 | 2.96 |

**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 | 473.00 | 495.00 | 486.00 | \ | 48.00 | 84.00 | 84.00 | \ | 3.00 |  | 2.70 | \ |
| Redap UE | \ | 50.00 | 49.00 | 51.00 | \ | 11.00 | 11.00 | 5.00 | \ |  |  | 1.20 |
| All UEs | 473.00 | 493.00 | 484.00 | 51.00 | 48.00 | 75.00 | 61.00 | 5.00 | 3.00 | 2.90 | 2.80 | 1.20 |
| Huawei | eMBB UE | 62.50 | 30.85 | 18.67 | \ | 19.05 | 8.71 | 5.08 | \ | 5.02 | 4.56 | 4.34 | \ |
| Redap 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 |  |
| Redap 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 | \ |
| Redap 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 | 489.57 | 489.57 | 489.55 | \ | 258.02 | 260.46 | 267.85 | \ | 7.86 | 7.86 | 7.86 | \ |
| Redap UE | \ | 35.20 | 34.83 | 34.78 | \ | 11.57 | 11.57 | 11.94 | \ | 2.11 | 2.11 | 2.11 |
| All UEs | 489.57 | 431.72 | 140.34 | 34.78 | 258.02 | 20.51 | 14.99 | 11.94 | 7.86 | 6.42 | 4.98 | 2.11 |

**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 | 376.00 | 393.00 | 402.00 | \ | 40.00 | 71.00 | 73.00 | \ | 2.90 |  |  | \ |
| Redap UE | \ | 49.00 | 50.00 | 50.00 | \ | 13.00 | 13.00 | 0.00 | \ |  |  | 1.90 |
| All UEs | 376.00 | 389.00 | 395.00 | 50.00 | 40.00 | 65.00 | 59.00 | 0.00 | 2.90 | 2.80 | 2.80 | 1.90 |
| Huawei | eMBB UE | 43.48 | 29.85 | 20.13 | \ | 11.30 | 6.81 | 4.88 | \ | 5.14 | 5.04 | 4.61 | \ |
| Redap UE | \ | 14.47 | 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 |  |
| Redap 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 | \ |
| Redap 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 | 371.06 | 372.96 | 373.12 | \ | 173.15 | 171.55 | 171.55 | \ | 6.20 | 6.20 | 6.20 | \ |
| Redap UE | \ | 18.68 | 18.75 | 19.66 | \ | 3.56 | 3.15 | 3.35 | \ | 1.79 | 1.79 | 1.79 |
| All UEs | 371.06 | 299.04 | 102.11 | 19.66 | 173.15 | 8.78 | 4.97 | 3.35 | 6.20 | 5.10 | 4.00 | 1.79 |

**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 | 376.00 | 384.00 | 396.00 | \ | 40.00 | 69.00 | 73.00 | \ | 2.90 |  |  | \ |
| Redap UE | \ | 38.00 | 39.00 | 34.00 | \ | 8.00 | 8.00 | 0.00 | \ |  |  | 1.50 |
| All UEs | 376.00 | 379.00 | 392.00 | 34.00 | 40.00 | 61.00 | 51.00 | 0.00 | 2.90 | 2.80 | 2.70 | 1.50 |
| Huawei | eMBB UE | 43.48 | 18.72 | 12.25 | \ | 11.30 | 4.08 | 2.54 | \ | 5.14 | 5.06 | 5.04 | \ |
| Redap 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 |  |
| Redap 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 | \ |
| Redap 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 | 371.06 | 372.96 | 373.12 | \ | 173.15 | 171.55 | 171.55 | \ | 6.20 | 6.20 | 6.20 | \ |
| Redap UE | \ | 17.71 | 17.46 | 17.47 | \ | 2.98 | 2.92 | 2.94 | \ | 1.60 | 1.60 | 1.60 |
| All UEs | 371.06 | 299.03 | 102.11 | 17.47 | 173.15 | 6.17 | 4.04 | 2.94 | 6.20 | 5.05 | 3.90 | 1.60 |

**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 | 49.000 | 49.000 | 49.000 | \ | 0.400 | 0.400 | 0.400 | \ | 0.400 |  |  | \ |
| Redap UE | \ | 16.000 | 16.000 | 16.000 | \ | 0.800 | 0.800 | 0.700 | \ |  |  | 0.500 |
| All UEs | 49.000 | 49.000 | 47.000 | 16.000 | 0.400 | 0.400 | 0.400 | 0.700 | 0.400 | 0.400 | 0.400 | 0.500 |
| Huawei | eMBB UE | 9.850 |  | 4.240 | \ | 0.210 |  | 0.240 | \ | 1.480 |  | 1.450 | \ |
| Redap UE | \ |  | 2.330 | 5.110 | \ |  | 0.200 | 0.240 | \ |  | 0.750 | 0.780 |
| All UEs | 9.850 |  | 3.290 | 5.110 | 0.210 |  | 0.200 | 0.240 | 1.480 |  | 1.070 | 0.780 |
| vivo | eMBB UE | 12.845 | 12.574 | 12.369 |  | 0.058 | 0.057 | 0.057 |  | 1.342 | 1.337 | 1.337 |  |
| Redap UE | \ | 0.582 | 0.635 |  | \ | 0.065 | 0.070 |  | \ | 0.317 | 0.316 |  |
| All UEs | 12.845 | 1.325 | 2.544 |  | 0.058 | 0.057 | 0.058 |  | 1.342 | 1.257 | 1.158 |  |
| Nokia | eMBB UE | 11.30 | 11.25 | 11.33 | \ | 5.73 | 5.77 | 5.73 | \ | 2.31 | 2.31 | 2.31 | \ |
| Redap UE | \ | 9.445 | 9.314 | 9.40 | \ | 3.520 | 3.754 | 3.92 | \ | 1.916 | 1.916 | 1.92 |
| All UEs | 11.30 | 10.652 | 10.167 | 9.40 | 5.73 | 4.962 | 4.519 | 3.92 | 2.31 | 2.214 | 2.115 | 1.92 |

**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 | 40.000 | 40.000 | 40.000 | \ | 0.300 | 0.300 | 0.300 | \ | 0.500 |  |  | \ |
| Redap UE | \ | 15.000 | 15.000 | 15.000 | \ | 0.600 | 0.600 | 0.500 | \ |  |  | 0.600 |
| All UEs | 40.000 | 39.000 | 38.000 | 15.000 | 0.300 | 0.300 | 0.300 | 0.500 | 0.500 | 0.500 | 0.500 | 0.600 |
| Huawei | eMBB UE | 8.450 | 6.110 | 4.070 | \ | 0.200 | 0.220 | 0.220 | \ | 1.860 | 2.200 | 2.050 | \ |
| Redap UE | \ | 2.840 | 2.410 | 3.790 | \ | 0.200 | 0.200 | 0.220 | \ | 0.730 | 0.890 | 1.250 |
| All UEs | 8.450 | 5.220 | 3.260 | 3.790 | 0.200 | 0.200 | 0.200 | 0.220 | 1.860 | 1.670 | 1.420 | 1.250 |
| vivo | eMBB UE | 5.265 | 5.894 | 0.946 |  | 0.058 | 0.058 | 0.056 |  | 1.336 | 1.336 | 1.320 |  |
| Redap UE | \ | 0.505 | 0.508 |  | \ | 0.034 | 0.028 |  | \ | 0.321 | 0.321 |  |
| All UEs | 5.265 | 2.976 | 0.640 |  | 0.058 | 0.057 | 0.055 |  | 1.336 | 1.274 | 1.153 |  |
| Nokia | eMBB UE | 9.21 | 9.19 | 9.00 | \ | 2.67 | 2.71 | 2.66 | \ | 2.26 | 2.26 | 2.26 | \ |
| Redap UE | \ | 6.910 | 7.013 | 6.98 | \ | 1.338 | 1.359 | 1.34 | \ | 1.907 | 1.907 | 1.91 |
| All UEs | 9.21 | 8.592 | 7.916 | 6.98 | 2.67 | 2.291 | 1.973 | 1.34 | 2.26 | 2.170 | 2.082 | 1.91 |

**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 |  |  | \ |
| Redap 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 |  |  | \ |
| Redap 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 | \ |
| Redap 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 |  |  | \ |
| Redap 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 |  |  | \ |
| Redap UE | \ |  |  | 48.00 | \ |  |  | 22.00 | \ |  |  | 2.2 |
| All UEs | 103.00 |  |  | 48.00 | 51.00 |  |  | 22.00 | 4.14 |  |  | 2.2 |
| Qualcomm | eMBB UE |  |  |  | \ |  |  |  | \ |  |  |  | \ |
| Redap 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 |  |  | \ |
| Redap 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 |  |  | \ |
| Redap 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 |  |
| Redap 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 |  |  | \ |
| Redap UE | \ | 171.00 | 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 |  |  | \ |
| Redap 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 |  |  | \ |
| Redap UE | \ | 54.00 | 53.00 | 49.00 | \ | 14.00 | 14.00 | 10.00 | \ |  |  | 0.90 |
| All UEs | 62.00 | 61.00 | 61.00 | 49.00 | 16.00 | 16.00 | 16.00 | 10.00 | 1.10 | 1.10 | 1.10 | 0.90 |

**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 |  |  | \ |
| Redap 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 |

**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 | \ |
| Redap 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 | \ |
| Redap 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 | \ |
| Redap 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 | \ |
| Redap 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 | \ |
| Redap 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 | \ |
| Redap 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 | \ |
| Redap 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 | \ |
| Redap 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 | \ |
| Redap 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 | \ |
| Redap 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 | \ |
| Redap 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 | \ |
| Redap 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. |
|  |  |  |

***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 user 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 |
|  |  |  |

# 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 user 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. |

## 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. |
|  |  |  |

## 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 |
|  |  |  |

## 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 |
|  |  |  |

## 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 |
|  |  |  |

# 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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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) | | |