**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 #4 on Coverage Recovery and Capacity Impact for RedCap

**Document for:** Discussion and Decision

# Introduction

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

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

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

In this round of the email discussion, please check the proposals/questions tagged ‘FL4’ (search for ‘FL4’).

# 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. |
| Lenovo, Motorola Mobility | Same question with ZTE, need to clarify if the reference UE is a Rel.17 UE or Rel.15/16 UE. Besides, we tend to agree with QC and Apple to discuss the bottleneck channels separately for those in initial access. |
| Ericsson | We are fine with the proposal provided it is further clarified how the representative value is determined. We think deleting the words “from the observations that need for compensation” is good. Does this then mean we allow the representative value to be determined based on both positive values +X dB (i.e. need coverage compensation of X dB) and negative values -Y (i.e. the channel has Y dB better than the link budget of the bottleneck channel(s) for the reference NR UE). We think this is better than simply averaging all the positive values. |
| CATT | We are fine with FL’s proposal. We think it is clear that the reference UE is a Rel-15/16 NR UE with mandatory capability w/o signaling only.  Regarding to the detail of how to use representative value, we agree that comparing representative value and zero can be the starting point at least.  We think Option 1 can be additional criteria for identifying the channels for coverage recovery. But results from Option3 and Option1 should be handled separately, not mixed with each other. |
| Intel | Regarding the FFS point, we prefer to consider a threshold for the representative value larger than 0, e.g., 0.5 ~ 1dB. It is observed from section 3 that the representative value for a channel could be positive after merging results from all companies. Having the threshold larger than 0 avoids a channel being deficient of compensation for any borderline cases.  While the suggestion from Qualcomm is appreciated, variations in the coverage performance across UEs with different data rate requirements are expected even within the population of eMBB UEs, this may not justify separate consideration between unicast and broadcast channels altogether.  The coverage performance for a UE includes both of these components and the observation “RedCap UEs will have worse coverage for initial access than Reference UE” may not reflect the practical scenario wherein the coverage of the Reference UE is actually defined by its worst-coverage channel, and lead to potential over-designing of the system in some cases.  A simpler approach to address a certain degree of variations across evaluations and operational data rates (for unicast) would be to just consider some additional margin in identifying the channels requiring coverage recovery, e.g., via a positive threshold for identification of a channel as requiring coverage recovery. |
| Xiaomi | For the first bullet, how to handle the relationship between option 1 (if agreed as additional criteria) and option 3 is not clear. To avoid the confusion, we suggest FL providing further clarification.  For the second bullet, we also share the same view with QC， the coverage of the initial access channels should be guaranteed. While how to achieve it could be further discussed. Generally, we think defining a second coverage recovery target or considering certain additional margin are both OK.  Maybe, for progress, we could firstly agree adopting option 3 in principle for the non-RA channels and leave the coverage recovery target of initial access channels for further study. |
| FL | Majority of the responses seems fine with the FL’ proposal. Several responses want to clarify whether the reference UE is a Rel-15/16 UE or not. One response proposed to include the case with the representative value equal to zero in the FFS part of the last bullet.  Four responses have pointed out the coverage issue of initial access channels for Option 3. Two responses stated there is no need to change definition of Option 3 to close the gap with the initial access channels for the reference UE. The FL suggests to further discuss for this issue.  A few responses also indicated to see the progress on Option 1. Since the scenario dependent target is being discussed in the CE SI, the FL suggestion is to focus on the need for Option 1 on condition that the scenario dependent target can be agreed by the Rel-17 CE SI.  **Based on the received responses, the FL made the following update for 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 a single coverage recovery target based on the same bottleneck channel is used for initial access channels and non-initial access channels of RedCap UE   + Further discussion whether Option 1 can be additional criteria for identifying the channels for coverage recovery   + Note: The reference UE is a Rel-15/16 NR UE with mandatory features only * 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~~ including both negative and non-negative values)   + Excluding the highest & the lowest values when the number of samples is more than 3   + If the number of samples used to compute a representative value is less than 4 for each scenario, this representative value is not used for bottleneck identification   + In this case, observations may still be drawn   + The representative value of a channel is used for identifying whether the channel needs coverage recovery   + Details are FFS (e.g. coverage recovery is not needed if the representative value of a channel is larger than or equal to zero)   Also, the FL invited companies to provide input to the FFS parts in the proposal in the following. |
| Samsung | In principle, we are OK with the updated proposal. One thing we’d like to point out is that DL/UL data rate in the simulation set-up is too high for RedCap especially, at the cell edge. If the data rate can be reduced considering practical situations, the MIL of the bottleneck channel (e.g., PUSCH) for reference UE would get close to PUCCH MIL which is higher than the MIL of PUSCH in general. In this case, MIL values for DL channel (e.g., PDCCH) for the RedCap may be lower than the MIL of the bottleneck channels. Due to the reason, we believe some impacts from reduced data rate for the RedCap should be taken into account. |
| InterDigital | We are fine with the updated proposal. |
| Ericsson | We are fine with the updated proposal. In our view, if the conclusion from the link budget evaluation is that the data channels for RedCap UEs would require coverage compensation, it is reasonable to trade data rate for coverage. |
| Huawei, Hisilicon | In our view, for Option3, the method of “representative value of the amount of compensation is derived by taking the mean value (in dB domain) from all the compensation values, which is a differential-value based method that was knocked out by absolute-value based method in CovEnh SI. We would like to avoid repeated discussions and focus on a similar absolute-value based method as CovEnh SI. For example, the representative value for the bottleneck channel of the NR reference UE should be developed first.  Agreements:   * Representative values of the absolute values of [MCL, MIL and MPL] are used for bottleneck identification   + Further down-selection one or more of MCL/MIL/MPL may be performed depending on the decision of target performance metric(s)   + Companies can also report their individual observations of the bottleneck based on individual simulation results   + How to use the respresentive values is FFS   + A representative value is derived by taking the mean value (in dB domain) from companies’ evaluation results     - 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   Additionally, we reiterate our comments that without considering in a reasonable deployment, it is insufficient to compensate the coverage gaps of bottleneck channels for RedCap UEs by comparing with bottleneck channels for reference UEs. The coverage of RedCap UEs can still be limited in the real network. It is not good for the business success for RedCap UEs. However, for Option1, the problem discussed above is not exist. Once the target ISD and channel model are determined, the target performance identified by all the companies will be same. And the real bottleneck channels can be identified naturally. Therefore, we would like to echo vivo’s view and propose the following to be incorporated into FL proposal,  ***Proposal:***   * *For Option 1, the target performance requirement is target MPL:* * *Target MPL corresponds to the distance of 2⁄(3\* ) ISD from the base station.* * *FR1: Urban macro ISD 350m, Rural ISD 1732m; FR2: indoor ISD 20m. (may be aligned with CovEnh SE if different ISD is agreed)* * *Companies’ target MPL are collected based on above assumptions. A representative value for target MPL of each scenario is derived by taking the mean value (in dB domain) with the same data preprocessing as agreed in CovEnh SI (i.e. conditional excluding the highest & the lowest values)* * *For Option 1, the amount of compensation for each channel by comparing the link budget of the channel with the representative value of target MPL:* * *A representative value of compensation for each channel is derived by taking the mean value (in dB domain) with the same data preprocessing as agreed in CovEnh SI (i.e. conditional excluding the highest & the lowest values)* |
| Qualcomm | We are fine with the updated proposal |
| FL4 | Regarding the comment on the absolute or differential value based representative value, the FL understanding is that for Option 3 we should focus on the relative performance gap between the RedCap UE and the reference NR UE instead of the absolute performance. We derive the representative value of the performance gap values by averaging over all the companies results and use it for identifying the channel for coverage recovery.  Secondly, it should be noted that the bottleneck channel for the reference NR UE could be different for each company. If the same bottleneck channel is reported by all the companies, then there is no difference between the absolute and differential value based representative value. For example, assuming A is a channel for ReCap UE and B is the bottleneck channel for reference NR UE, then the absolute-value based representative value is given by mean(A) – mean(B) and the differential-value based representative value is given by mean (A – B). Although skipping the highest and lowest value may cause difference, but it should be small. However, if the bottleneck channel is different by each company (e.g. channel B by company 1 and channel C by company 2), then for the absolute value based representative value, we need to firstly align on the bottleneck channel for the reference NR UE. Also, the result from averaging over all the companies’ results may result in a relatively larger target value. For example, B1=10, C1=20 from company 1 and B2=20, C2=10 from company 2, then the representative value for the bottleneck channel will be min(mean(B1,B2), mean (C1, C2)) = 15, which will be larger than taking the minimum value from each company. So, the FL thinks the absolute value based representative value may artificially increase the recovery target.  Regarding Option 1 vs. Option 3, the FL understanding is that Option 3 is preferred by majority of companies, and some companies also indicate potential risk for using a single option in some cases. Therefore, the FL proposes to further discuss whether Option 1 can be additional criteria for coverage recovery. At this moment, it is not acceptable to remove Option 3.  **[FL4] Proposal 2.1-1**   * 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 a single coverage recovery target based on the same bottleneck channel is used for initial access channels and non-initial access channels of RedCap UE   + Further discussion whether Option 1 can be additional criteria for identifying the channels for coverage recovery   + Note: The reference UE is a Rel-15/16 NR UE with mandatory features only * For Option 3, companies report their individual observations of the amount of compensation for each channel by comparing the link budget with that of the bottleneck channel for the reference NR UE (i.e. the LB of the channel for RedCap UE – the LB of the bottleneck channel for the reference UE)   + A representative value of the amount of compensation is derived by taking the mean value (in dB domain) from all the compensation values including both negative and non-negative values   + Excluding the highest & the lowest values when the number of samples is more than 3   + If the number of samples used to compute a representative value is less than 4 for each scenario, this representative value is not used for bottleneck identification   + In this case, observations may still be drawn   + The representative value of a channel is used for identifying whether the channel needs coverage recovery   + Details are FFS (e.g. coverage recovery is not needed if the representative value of a channel is larger than or equal to zero) |
| vivo | We see some further progress in CE SI regarding the target ISD in FR2 as the following. We should reuse these ISD values for Option 1 for identify the target for coverage compensation.  **Agreements :**  If absolute ISD/MPL targets are agreed to be used for coverage bottleneck identification then the following targets are considered for FR2:   * + **Dense Urban**: ISD = 200m; MPL = [123.1] dB;   + **Indoor**: ISD = [20]m; MPL = [94.03] dB |
| Qualcomm | We are fine with the FL updated proposal |
| Huawei, Hisilicon | Firstly, echo vivo on reusing ISD values agreed in CovEnh SI for Option 1.  Secondly, regarding how to handle large variance of reported results, we would like to suggest to reuse the outcome of CovEnh SI, especially how to achieve representative value. Otherwise, some discussions seems to be repeated, e.g. differential value v.s. absolute values for Option 3. More details can be found in our previous comments.  Thirdly, we would like to treat the development of Option1 and Option3 equally if no down-selection is made first. Please give us a chance to contribute to the completion of Option1.  Fourthly, please take into consideration to reuse the latest agreement made in CovEnh SI for the calculation of ISD to MPL.  Additionally, we reiterate our comments that without considering in a reasonable deployment, it is insufficient to compensate the coverage gaps of bottleneck channels for RedCap UEs by comparing with bottleneck channels for reference UEs. The coverage of RedCap UEs can still be limited in the real network. It is not good for the business success for RedCap UEs. However, for Option1, the problem discussed above is not exist. Once the target ISD and channel model are determined, the target performance identified by all the companies will be same. And the real bottleneck channels can be identified naturally. Therefore, we would like to echo vivo’s view and propose the following to be incorporated into FL proposal,  ***Proposal:***   * *For Option 1, the target performance requirement is target MPL:* * *Target MPL corresponds to the distance of 2⁄(3\* ) ISD from the base station.* * *FR1: Urban macro ISD 350m, Rural ISD 1732m; FR2: indoor ISD 20m. (may be aligned with CovEnh SI if different ISD is agreed)* * *Reuse the ISD-to-MPL formula agreed in CovEnh SI* * *Companies’ target MPL are collected based on above assumptions. A representative value for target MPL of each scenario is derived by taking the mean value (in dB domain) with the same data preprocessing as agreed in CovEnh SI (i.e. conditional excluding the highest & the lowest values)* * *For Option 1, the amount of compensation for each channel by comparing the link budget of the channel with the representative value of target MPL:* * *A representative value of compensation for each channel is derived by taking the mean value (in dB domain) with the same data preprocessing as agreed in CovEnh SI (i.e. conditional excluding the highest & the lowest values)*   For option1, the following agreements made in CovEnh SI can be reused directly:   * + For, Scenario dependent targets, e.g., ISD/MPL     - * The following formula is used to convert an ISD value to a target MPL value (to add the reference when capturing into TR):         + For urban scenarios,      * + - * + For rural scenarios,      * + - * + For rural with long distance scenarios (working assumption) |
| Futurewei | A few comments in regard to the proposal:  we think this sub-sub-sub-bullet  Further discussion whether a single coverage recovery target based on the same bottleneck channel is used for initial access channels and non-initial access channels of RedCap UE  is not needed as it was agreed in GTW to do the down-selection.  It is not very clear how the following sub-bullet   * + Further discussion whether Option 1 can be additional criteria for identifying the channels for coverage recovery   will be used as additional criteria, is it to be used as additional criteria for Option 3 on top of the two alternatives? More details are needed at this point hopefully using available decisions from the CE SI.  On the sub-bullet   * + Details are FFS (e.g. coverage recovery is not needed if the representative value of a channel is larger than or equal to zero)   There seems to be no reason to make it FFS so a better formulation may be   * + The representative value of a channel is used for identifying whether the channel needs coverage recovery     - coverage recovery is not needed if the representative value of a channel is larger than or equal to zero     - the amount of coverage recovery to recommend will depend on further discussion of the techniques, scenarios, etc   We still support a common target for all channels for option 3. That is we support Alt 1 that is the current definition of Option 3. We feel the Alt2 serves the purpose of creating an amount of compensation for certain channels that may not need compensation otherwise. The intent now appears to be to push lots of coverage recovery that is unwarranted. Similar to the initial proposal by the FL in the previous summary FLS2:   * A small amount of compensation (e.g. up to 3-4 dB) can be considered for a channel if the link budget for the channel exceeds that of the bottleneck channel for the reference NR UE but the margin is small |
| Intel | We prefer to adopt Option 3 only. |
| Ericsson | We agree with FL’s comment and prefer differential-value based representative value.  In our view, the methodology based on Option 3 is much more mature than that based on Option 1. |
| Samsung | OK with the FL’s proposal. |
| Lenovo, Motorola Mobility | In general we agree with FL’s proposal. The sub-bullet below could be deleted based on the agreements (two Alts for option3) in the last GTW meeting.   * Further discussion whether a single coverage recovery target based on the same bottleneck channel is used for initial access channels and non-initial access channels of RedCap UE |
| FL4 | Based on the response, majority of companies are fine with the FL’s proposal. Only two companies have concerns on using Option 3 for determining the coverage recovery target.  Regarding the agreement in the CE SI for the target ISD/MPL, the FL’s understanding is that the agreement is about how to convert an ISD value to a target MPL, and it is unclear how a target MPL is used for bottleneck identification. Secondly, the ISD value for indoor scenario is not agreed (i.e. in a bracket now), and the ISD values for other scenarios are still under discussion. Furthermore, the ISD values discussed in the CE SI are target for Rel-17 UE capable of coverage enhancement. It may be too high for the RedCap UE. That is, if a high target is used, some high complexity techniques are required for the RedCap UE for improving coverage, which will contradict with the objective of RedCap. Considering all these factors, the FL thinks it is not mature now to consider using Option 1 for identifying the channels to compensate. That is the reason why the FL proposes to further discuss Option 1 considering the decision from the CE SI.  Two responses proposed to remove the first FFS from the proposal since it has been agreed in GTW to do the down-selection.  For the FFS part in the last sub-bullet, FL supports to make further progress. Based on the response to Proposal 2.1-3, seems majority of companies are fine with “coverage recovery is not considered for a channel if the representative value of the channel is larger than or equal to zero”, and several response indicate to decide the amount of compensation later.  Based on the response, the FL’s updated suggestion is the following:  **[FL4] Updated Proposal 2.1-1**   * 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 a single coverage recovery target based on the same bottleneck channel is used for initial access channels and non-initial access channels of RedCap UE~~   + Further discussion whether Option 1 can be ~~additional criteria~~ used for identifying the channels for coverage recovery considering the decision from the CE SI   + Note: The reference UE is a Rel-15/16 NR UE with mandatory features only * For Option 3, companies report their individual observations of the amount of compensation for each channel by comparing the link budget with that of the bottleneck channel for the reference NR UE (i.e. the LB of the channel for RedCap UE – the LB of the bottleneck channel for the reference UE)   + A representative value of the amount of compensation is derived by taking the mean value (in dB domain) from all the compensation values including both negative and non-negative values     - Excluding the highest & the lowest values when the number of samples is more than 3     - If the number of samples used to compute a representative value is less than 4 for each scenario, this representative value is not used for bottleneck identification     - In this case, observations may still be drawn   + The representative value of a channel is used for identifying whether the channel needs coverage recovery     - ~~Details are FFS (e.g.~~ Coverage recovery is not needed if the representative value of a channel is larger than or equal to zero~~)~~     - The amount of coverage recovery to recommend will depend on further discussion of the techniques, scenarios, etc |
| LG | We are generally fine with FL’s proposal. Also, we prefer to take option 3 only. |
| CMCC | Agree with Huawei, Option 1 can reflect the realistic deployment of network. Some companies propose the coverage problem during initial access procedure of RedCap UEs and using alt 2 to solve this issue, we think Option 1 itself can solve these problems, because the all the channels including initial access channels can reach the target MPL/coverage after using some coverage recovery solutions.  The proposal about Option 1 methodology suggested by Huawei is a good starting point to make the process. |
| vivo | We have concern about **[FL4] Updated Proposal 2.1-1**, in particular how option 1 is treated. Given some progress has been made for target ISD in CE SI, we suggest that option 1 can also be used for the scenarios with agreed ISD/MPL target from CE SI. An revised version is provided as below (revisions shown in blue text)   * ~~Agree in principle using~~ Option 3 can be used 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 a single coverage recovery target based on the same bottleneck channel is used for initial access channels and non-initial access channels of RedCap UE~~   + Note: The reference UE is a Rel-15/16 NR UE with mandatory features only * ~~Further discussion whether~~ Option 1 can also be ~~additional criteria~~ used for identifying the channels for coverage recovery ~~considering the decision~~ for the scenarios with agreed ISD/MPL target from the CE SI   + For FR2 Indoor : target ISD = [20]m; MPL = [94.03] dB   + For other scenarios: TBD * For Option 3, companies report their individual observations of the amount of compensation for each channel by comparing the link budget with that of the bottleneck channel for the reference NR UE (i.e. the LB of the channel for RedCap UE – the LB of the bottleneck channel for the reference UE)   + A representative value of the amount of compensation is derived by taking the mean value (in dB domain) from all the compensation values including both negative and non-negative values     - Excluding the highest & the lowest values when the number of samples is more than 3     - If the number of samples used to compute a representative value is less than 4 for each scenario, this representative value is not used for bottleneck identification     - In this case, observations may still be drawn   + The representative value of a channel is used for identifying whether the channel needs coverage recovery     - ~~Details are FFS (e.g.~~ Coverage recovery is not needed if the representative value of a channel is larger than or equal to zero~~)~~     - The amount of coverage recovery to recommend will depend on further discussion of the techniques, scenarios, etc |
| Futurewei | OK |
| Huawei, HiSilicon | Firstly, we echo vivo’s view that it should be clear how Option 1 is treated in the proposal. Agree with CMCC, a starting point for Option 1 is needed. As proposed before, at least some agreed methodologies can be reused here.  Secondly, regarding the differentiate value in Option 3 is derived based on a bottleneck channel, whose definition has been agreed before. But it is unclear in the new proposal, resulting in useless mean value of representative values of differentiate values if companies have no aligned bottleneck channel as a target. Therefore, a note copied from agreement is suggested.  Thirdly, regarding the example provided by FL to justify differential values “*For example, B1=10, C1=20 from company 1 and B2=20, C2=10 from company 2, then the representative value for the bottleneck channel will be min(mean(B1,B2), mean (C1, C2)) = 15, which will be larger than taking the minimum value from each company.*”, we don’t find such instance from companies results and it seem to worry about something that does not exist. Could FL please point out which channel from which company’s results?  In summary, we propose changes on top of vivo’s version (in green),   * ~~Agree in principle using~~ Option 3 can be used 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 a single coverage recovery target based on the same bottleneck channel is used for initial access channels and non-initial access channels of RedCap UE~~   + Note: The reference UE is a Rel-15/16 NR UE with mandatory features only * ~~Further discussion whether~~ Option 1 can also be ~~additional criteria~~ used for identifying the channels for coverage recovery ~~considering the decision~~ for the scenarios with agreed ISD/MPL target from the CE SI   + For FR2 Indoor : target ISD = [20]m; MPL = [94.03] dB   + FR1: Urban macro ISD 350m, Rural ISD 1732m;   + For other scenarios: TBD   + Reuse the ISD-to-MPL formula agreed in CovEnh SI   + A representative value for target MPL of each scenario is derived by the same method agreed in CovEnh SI (i.e. mean value with conditional excluding the highest & the lowest values)   + The amount of compensation for each channel by comparing the link budget of the channel with the representative value of target MPL:   + A representative value of compensation for each channel can be derived by the same method as agreed in CovEnh SI. * 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)   + Note: The “bottleneck channel(s)” are the physical channel(s) that have the lowest MIL   + A representative value of the amount of compensation is derived by taking the mean value (in dB domain) from all the compensation values including both negative and non-negative values     - Excluding the highest & the lowest values when the number of samples is more than 3     - If the number of samples used to compute a representative value is less than 4 for each scenario, this representative value is not used for bottleneck identification     - In this case, observations may still be drawn   + The representative value of a channel is used for identifying whether the channel needs coverage recovery     - ~~Details are FFS (e.g.~~ Coverage recovery is not needed if the representative value of a channel is larger than or equal to zero~~)~~     - The amount of coverage recovery to recommend will depend on further discussion of the techniques, scenarios, etc |
| Spreadtrum | We support views of HW, CMCC and vivo to start defining details of Option 1 from now, since CE topic also adopted the similar mechanism. For concern of Option 1 that the complex mechanism may be introduced for RedCap UE, in our view there could be a slight complex increase for network to support 1RX and limited form size UE, and it is meaningful to make the wearables more popular in real world. Otherwise, the compensation solely from UE receiver implementation will lead to the expensive and unpopular wearables.  For Option 1, the conclusion of CE topic can be the starting point, as Operator has given the typical ISD/MPL values. |
| Nokia, NSB | We are fine with the FL’s proposal |

Agreements on 11/3 GTW session:

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

**Question 2-2:** **Companies are invited to input further views for the above two alternatives**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option** | **Comments** |
| vivo | Option 2 | We are generally supportive to option 2 as we see the risk for initial access channels by using option 3 as the coverage recovery target. One suggested revision as following to make the proposal clearer.   * + Option 2: Identify 2 coverage recovery targets for the RedCap UE initial access channels and non-initial access channels, respectively:   + The 1st target (for initial access channels) is based on the bottleneck channel among the initial access channels of the reference NR UE   + The 2nd target (for non-initial access channels) is based on the bottleneck channel among all the channels of the reference NR UE |
| Samsung | Option 2 | We can go with Option 2 because it can compensate for coverages of DL channels significantly reduced due to potential RedCap features. |
| LG | Option 1 | We prefer to focus on the channel that cannot meet the performance of the reference (Rel-15/16) NR UEs. We don't think there is a strong motivation to enhance the coverage of the initial access channels. |
| Futurewei | Option 1 | Don’t think there is a need to introduce two targets. Option 3 should not be redefined |
| Ericsson | Option 2 | We prefer Option 2 from technical point of view. |
| InterDigital | Option 2 |  |
| Qualcomm | Option 2 |  |
| FL4 | The FL made an initial estimate of the coverage loss for the two alternatives. As seen from tables below, Alt. 2 may require also DL recovery for FR1 and the potential amount of compensations is moderate. Compared to Alt. 1, the coverage of initial access channels for RedCap UE will be compensated to be comparable to that of the reference NR UE. Therefore, the FL suggestion is to adopt Alt. 2.  Table: Coverage loss based on Alt. 1   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | Urban 2.6 GHz | Rural 700 MHz | Urban 4 GHz | Indoor 28 GHz, 100MHz BW | Indoor 28 GHz, 50MHz BW | | UL | PUSCH (3 dB) | PUSCH (3 dB) | PUSCH (3 dB) | N.A. | N.A. | | Msg3 (0.8 dB) | | DL, 2Rx | N.A. | N.A. | N.A. | N.A. | PDSCH (2.7 dB) | | | DL, 1Rx | N.A. | N.A. | Msg2 (0.7 dB) | PDSCH (3.1 dB) | PDSCH (7.8 dB) | | Msg2 (1.2 dB) | Msg2 (2.3 dB) | | Msg4 (0.7 dB) | Msg4 (1.9 dB) | |  | PDCCH CSS (1.4 dB) |   Table: Coverage loss based on Alt. 2   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | Urban 2.6 GHz | Rural 700 MHz | Urban 4 GHz | Indoor 28 GHz, 100MHz BW | Indoor 28 GHz, 50MHz BW | | UL | PUSCH (3 dB) | PUSCH (2.9 dB) | PUSCH (3 dB) | N.A. | N.A. | | Msg (3.0 dB) | Msg (3.0 dB) | Msg3 (1.3 dB) | | DL, 2Rx | N.A. | N.A. | Msg2 (1.8 dB) | N.A. | PDSCH (2.7 dB) | | Msg4 (0.5 dB) | Msg2 (2.5 dB) | |  | Msg4 (3.2 dB) | | DL, 1Rx | Msg2 (2.7 dB) | Msg2 (0.9 dB) | Msg2 (7.2 dB) | PDSCH (3.1 dB) | PDSCH (7.8 dB) | | Msg4 (4.8 dB) | Msg2 (4.0 dB) | Msg2 (4.6 dB) | | PDCCH CSS (2.8 dB) | Msg4 (3.8 dB) | Msg4 (4.8 dB) | |  | PDCCH CSS (2.1 dB) | PDCCH CSS (1.8 dB) |   **[FL4] Proposal 2.1-2:** Adopt Alt. 2 for Option 3 | |
| vivo |  | For scenarios that target ISD can be given (so far the ISD [20]m has been agreed for FR2 indoor scenario in CE SI), we can use Option 1 to guarantee the initial access for RedCap UEs, no need to further optimize option 3. In particular, in FR2 indoor, it has been observed no coverage recovery needed for [20]m ISD while conflict observation is given based on alt 2 of Option 3, which can be misleading and may cause overcompensation.  In case we could not reach consensus on target ISD for some specific scenario, alt 2 for Option 3 can be considered to guarantee the initial access. |
| Qualcomm |  | We are fine with the FL updated proposal |
| Huawei, HiSilicon |  | Agree with vivo that no need to spend more time to discuss Alt.2. In previous agreement for Option 3, only the lowest MCL or MIL or MPL can be the bottleneck, which means Alt.1 only.  We don’t see any need to overturn the agreement. If some companies worry the initial access channels would be the bottleneck channels, the target performance of option 1 seems more reasonable to solve the problem. |
| Futurewei | N | We do not agree with adoption of alternative 2. Prefer to stay with alternative 1 of option 3 i.e. the current definition of option3. It is clear that with Alt2 more coverage is needed while companies have shown with the current definition of Alt1 little to no compensation may be needed.  The "(s)" was intended for cases where there was a tie, or where different scenarios had different bottleneck channels.  We should not try to redefine Option 3 in order to compensate for "performance losses" which do not impact coverage as this is against the SI. |
| Intel | Y | We support the FL proposal |
| Ericsson | Y | We are fine with the FL’s updated proposal. |
| Samsung | Y | OK with the FL proposal. |
| Lenovo, Motorola Mobility | Y | We are fine with the FL’s proposal.  We provided the evaluation results for 4GHz case in table 3.3-1 and 3.3-3. It is appreciated that FL could take our evaluations into account. |
| CATT | N | We have similar views with vivo, HW and Futurewei. In our understanding, a reasonable deployment shall already meet the transmission requirement of the bottleneck channel of the reference NR UE (even with some margin). Single coverage recovery target is enough to find out the gap of each channel of RedCap UE to be served in the network successfully. Not necessary to overturn the agreement.  If companies have concerns about the performance of RACH channels, it can be further considered whether a recovery margin can be introduced to some of them based on Alt.1. |
| Apple | Yes | We are supportive for FL proposal. As commented earlier, it was observed in real deployment scenario that initial access channels become bottleneck for wearable devices and cause the access failure and coverage problem, although the PUSCH is still doable with very low code rate. Note that although it depends on the operator choice, target data rate (e.g. 2Mbps) maybe not used to limit the cell size, which causes the coverage problem for wearable devices. |
| ZTE | Y | We support the FL proposal. |
| LG | N | Prefer Alt 1. Regardless of whether the UE's initial access is successful or not, the coverage of the RedCap UE is limited by the channel with the worst coverage performance.  Minor comment: typo in a Table of Alt. 2 : Msg 🡪 Msg3 |
| CMCC |  | Agree with Huawei and vivo. |
| InterDigital | Y |  |
| Spreadtrum |  | Agree with Huawei and vivo. |
| Nokia, NSB | Y |  |

**Proposal #3**

* Coverage recovery is not considered if the representative value of a channel is larger than or equal to X
  + Option 1: X=0
  + Option 2: X is a value between 0.5 and 1dB.

**Question 2-3:** **Companies are invited to input views for the above moderator’s proposal #3**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option** | **Comments** |
| vivo | None | We think there is no strong need to decide a exact value for X, we think the threshold can be decided case by case for different channels.  We think the more critical issue is how to deal with the large range of reported dB numbers among companies for coverage compensation. |
| Samsung | Option 1 | We think Option 1 is reasonable. For Option 2, it is unclear why 0.5 or 1dB should be selected as a range of X. |
| LG | Option 1 | Our target in this agenda is to compensate coverage loss due to the complexity reduction, not enhancement. Furthermore, potential increase in complexity for the coverage compensation is not preferred. |
| Futurewei | Option 1 |  |
| Ericsson | Option 1 |  |
| InterDigital | Option 1 |  |
| Qualcomm | Option 1 |  |
| FL4 | For the proposal to decide the X value case by case, FL thinks it is too complicated and not acceptable. Regarding the large range of the reported values, FL notes that the use of representative value can at least remove some outliers. The value range after removing the highest and lowest value from the list is significantly reduced and not so high.  Therefore, the FL suggestion is to adopt X=0.  **[FL4]: Proposal 2.1-3:**   * For Option 3, coverage recovery is considered for a channel if the representative value of the channel is less than zero and the amount of coverage recovery is defined by the absolute value of the representative value | |
| vivo |  | It would be appreciated if FL can provide some updated statistics showing how the range of reported results can be significantly reduced after removing the outliers? Thanks a lot.  Imagine a case where most companies reported small positive values (no compensation needed) while few companies reported very large negative values (large compensation needed) resulting a very small negative representative value (e.g. -0.2dB), should the channel be enhanced? To us it should be no for such case.  Even though we are not sure if such case indeed exists based on the submitted results but it may happen theoretically. To make sure we are not mandated to do coverage recovery for such cases, suggest a slight wording revision.  **[FL4]: Proposal 2.1-3:**  For Option 3, coverage recovery ~~is~~ may be considered for a channel if the representative value of the channel is less than zero and the amount of coverage recovery is defined by the absolute value of the representative value  In addition, for channels with different formats, e.g. PRACH with different formats (corresponding to different coverage) and PUCCH with different payloads, it will be necessary to make the observation for different formats separately and the channel is considered for coverage recovery if the format with best coverage cannot reach the coverage target. |
| Qualcomm |  | We are fine with the FL updated proposal |
| Huawei, Hisilicon | None | It is unclear what representative value is in the proposal. We prefer to wait until proposal 1 is agreed. |
| Futurewei | Y |  |
| Intel |  | We are fine for the FL proposal |
| Ericsson |  | We are fine with “coverage recovery is considered for a channel if the representative value of the channel is less than zero”.  But we suggest leaving the issue of “amount of coverage recovery” as FFS. We prefer to have a holistic view on the representative values for all the scenarios first.  So our suggestion:  “For Option 3, coverage recovery is considered for a channel if the representative value of the channel is less than zero   * FFS: how the amount of coverage recovery is determined by the absolute value of the representative value” |
| Samsung | Y | OK with the FL proposal. |
| Lenovo, Motorola Mobility | Y | Fine with the FL’s proposal. |
| CATT | Y | For Option 1, though may not be perfect, the meaning is clear. Representative value >= X=0 means the LB of a channel is better than the target one, at least in the average sense.  For Option 2, it is hard to judge what detail value X should be and why such value is determined. But we are open to Option2 if technical reasons are found to provide a solid value X. |
| FL4 | The proposal 2.1.-3 has been merged with the updated proposal 2.1-1. The discussion can be closed. For the comments raised by vivo, we can have further discussion when making the summary observation | |

**Question 2-4:** **On condition that the Rel-17 CE SI has reached agreements on the scenario dependent target, e.g., ISD/MPL, can Option 1 with the same target be used additionally for identifying the channels for coverage recovery? If yes, please indicate your preferred options to handle the results from Option 1 and Option 3?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | Y | We think option 1 should be look at together with option 3 do make the conclusion.  For example, for a particular channel, if coverage issue is identified from both option 1 and option 3, the channel can be recommended for coverage compensation. Otherwise, if coverage issue is only identified by one option but not the other, we need to discuss case by case for the recommendation. |
| Samsung | N | We think Option 3 is sufficient. |
| LG | N |  |
| Futurewei |  | If group decides on reasonable values then yes if not then prefer option 3. |
| Ericsson | N | We think option 3 is sufficient. |
| InterDigital | N | We think option 3 is sufficient. |
| FL4 | The CE SI has not agreed the exact value of target MPL/ISD for all the scenarios and the FL suggests to further discuss whether Option 1 can be used as additional criteria and how to handle the results from Option 1 and 3 especially when there is conflict. FL will make a proposal based on the companies’ input. | |
| vivo |  | As commented before, CE SI has already made the following agreement. We should use the same ISD for FR2 and further decide the ISD target for FR1.  **Agreements :**  If absolute ISD/MPL targets are agreed to be used for coverage bottleneck identification then the following targets are considered for FR2:   * + **Dense Urban**: ISD = 200m; MPL = [123.1] dB;   + **Indoor**: ISD = [20]m; MPL = [94.03] dB |
| Huawei, Hisilicon | Y | We reiterate our comments that without considering in a reasonable deployment, it is insufficient to compensate the coverage gaps of bottleneck channels for RedCap UEs by comparing with bottleneck channels for reference UEs. The coverage of RedCap UEs can still be limited in the real network. It is not good for the business success for RedCap UEs. Therefore, we would like to propose the following to be incorporated into FL proposal,  ***Proposal:***   * *For Option 1, the target performance requirement is target MPL:* * *Target MPL corresponds to the distance of 2⁄(3\* ) ISD from the base station.* * *FR1: Urban macro ISD 350m, Rural ISD 1732m; FR2: indoor ISD 20m. (may be aligned with CovEnh SI if different ISD is agreed)* * *Reuse the ISD-to-MPL formula agreed in CovEnh SI* * *Companies’ target MPL are collected based on above assumptions. A representative value for target MPL of each scenario is derived by taking the mean value (in dB domain) with the same data preprocessing as agreed in CovEnh SI (i.e. conditional excluding the highest & the lowest values)* * *For Option 1, the amount of compensation for each channel by comparing the link budget of the channel with the representative value of target MPL:* * *A representative value of compensation for each channel is derived by taking the mean value (in dB domain) with the same data preprocessing as agreed in CovEnh SI (i.e. conditional excluding the highest & the lowest values)*   For option1, the following agreements made in CovEnh SI can be reused directly:   * + For, Scenario dependent targets, e.g., ISD/MPL     - * The following formula is used to convert an ISD value to a target MPL value (to add the reference when capturing into TR):         + For urban scenarios,      * + - * + For rural scenarios,      * + - * + For rural with long distance scenarios (working assumption) |
| Futurewei |  | Not clear how additional criteria is going to be used. May need more details on this |
| Intel |  | We think Option 3 is sufficient. |
| Ericsson |  | We think option 3 is sufficient. |
| CATT |  | We think it is helpful to consider Option 1. However, we afraid that for the case if coverage issue a specific channel is only identified by one option but not the other, we will spend too much time on discussion, considering the limit time. |
| ZTE |  | We prefer Option 3. In case Option 1 is considered, we prefer to discuss this question after the targets for all related scenarios are available from NR CE. |
| LG |  | We prefer Option 3. |
| CMCC |  | We prefer Option 1. |
| Nokia, NSB |  | We prefer Option 3 and option 3 alone is sufficient |

# 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) | 164.47 | 168.47 | 166.15 | 160.47 | 162.55 |  | 160.6 |  | 156.4 | 143.24 | 152.84 |  | 143.24 |
| Margin (dB) | 21.23 | 25.23 | 22.91 | 17.23 | 19.31 |  | 17.36 |  | 13.16 | 0.0 | 9.6 |  |  |
| Qualcomm | MIL (dB) | 161.3 |  | 163.4 | 158.3 | 159.8 |  |  |  | 146.5 | 139.4 | 148.2 |  | 139.4 |
| Margin (dB) | 22.0 |  | 24.0 | 18.9 | 20.4 |  |  |  | 7.2 | 0.0 | 8.9 |  |  |
| Intel | MIL (dB) | 165.7 | 166.9 | 163.5 | 166.4 | 164.1 | 165.7 | 162.0 | 160.8 | 158.2 | 143.9 | 154.6 | 156.8 | 143.9 |
| Margin (dB) | 21.7 | 23.0 | 19.6 | 22.4 | 20.1 | 21.8 | 18.1 | 16.8 | 14.2 | 0.0 | 10.6 | 12.8 |  |

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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



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

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

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

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

**Moderator’s observation**

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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



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

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

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

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

**Moderator’s observation**

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

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

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

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

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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Indoor, 28GHz, 100MHz, 2Rx Ref NR UE** | | | | | | | | | | | | | | |
|  |  | PDCCH CSS | PDCCH USS | PDSCH | Msg2 | Msg4 | PBCH | PUCCH 2bits | PUCCH 11 bits | PUCCH 22bits | PUSCH | Msg3 | PRACH | Target /Option3 |
| Samsung | MIL (dB) | 146.5 | 146.5 | 141.3 | 145.1 | 142.5 |  | 157.8 | 153.8 | 150.9 | 133.3 | 149.4 |  | 133.3 |
| Margin (dB) | 13.2 | 13.2 | 8.0 | 11.8 | 9.2 |  | 24.5 | 20.5 | 17.6 | 0.0 | 16.1 |  |  |
| ZTE | MIL (dB) | 139.8 | 140.5 | 134.5 | 139.0 | 139.3 |  | 157.5 | 153.1 | 152.3 | 134.3 | 152.3 |  | 134.3 |
| Margin (dB) | 5.5 | 6.2 | 0.2 | 4.6 | 4.9 |  | 23.1 | 18.8 | 18.0 | 0.0 | 18.0 |  |  |
| OPPO | MIL (dB) | 145.9 | 145.9 | 142.9 | 144.6 | 144.2 |  | 160.0 | 159.7 | 160.0 | 141.9 | 160.2 |  | 141.9 |
| Margin (dB) | 4.0 | 4.0 | 1.0 | 2.8 | 2.3 |  | 18.2 | 17.8 | 18.1 | 0.0 | 18.4 |  |  |
| vivo | MIL (dB) | 135.5 | 140.5 | 136.0 | 133.7 | 135.1 | 139.8 | 153.9 | 152.3 | 149.0 | 131.4 | 142.8 | 142.6 | 131.4 |
| Margin (dB) | 4.1 | 9.1 | 4.6 | 2.3 | 3.8 | 8.4 | 22.6 | 20.9 | 17.6 | 0.0 | 11.4 | 11.2 |  |
| Nokia | MIL (dB) | 142.5 | 142.5 | 139.3 | 144.9 | 144.1 |  | 160.5 |  | 158.9 | 144.9 | 153.1 | 157.5 | 139.3 |
| Margin (dB) | 3.3 | 3.3 | 0.0 | 5.6 | 4.8 |  | 21.2 |  | 19.6 | 5.6 | 13.8 | 18.2 |  |
| DOCOMO | MIL (dB) | 148.6 | 148.6 | 143.0 | 143.3 | 142.0 |  | 158.6 | 164.0 |  | 147.3 | 160.3 |  | 142.0 |
| Margin (dB) | 6.6 | 6.6 | 1.0 | 1.3 | 0.0 |  | 16.6 | 22.0 |  | 5.4 | 18.3 |  |  |
| Ericsson | MIL (dB) | 132.1 | 133.1 | 128.4 | 128.2 | 128.0 | 134.3 | 150.5 | 150.9 | 148.4 | 138.7 | 146.3 | 149.1 | 128.0 |
| Margin (dB) | 4.1 | 5.1 | 0.4 | 0.2 | 0.0 | 6.3 | 22.5 | 22.9 | 20.4 | 10.7 | 18.3 | 21.1 |  |
| InterDigital | MIL (dB) | 147.3 | 147.3 | 142.67 | 143.32 | 142.47 |  | 166.3 |  | 160.7 | 143.4 | 159.35 |  | 142.47 |
| Margin (dB) | 4.8 | 4.8 | 0.2 | 0.85 | 0.0 |  | 23.83 |  | 18.2 | 0.9 | 16.88 |  |  |
| Qualcomm | MIL (dB) | 143.4 | 149.4 | 141.9 | 143.9 | 147.3 | 153.0 | 170.8 | 164.7 | 162.2 | 138.8 | 147.4 | 163.4 | 138.8 |
| Margin (dB) | 4.6 | 10.6 | 3.1 | 5.1 | 8.5 | 14.1 | 32.0 | 25.8 | 23.3 | 0.0 | 8.6 | 24.6 |  |
| Intel | MIL (dB) | 139.2 | 140.0 | 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 | 138.56 | 138.0 | 137.90 |  | 166.3 |  | 160.7 | 143.4 | 159.35 |  | 142.47 |
| Margin (dB) | 1.0 | 1.0 | -3.9 | -4.47 | -4.57 |  | 23.9 |  | 18.2 | 0.9 | 16.88 |  |  |
| Qualcomm | MIL (dB) | 140.1 | 146.1 | 137.7 | 138.5 | 143.8 | 149.7 | 170.8 | 164.7 | 162.2 | 138.8 | 147.4 | 163.4 | 138.8 |
| Margin (dB) | 1.3 | 7.3 | -1.2 | -0.4 | 5.0 | 10.8 | 32.0 | 25.8 | 23.3 | 0.0 | 8.6 | 24.6 |  |
| Intel | MIL (dB) | 135.1 | 135.9 | 128.0 | 137.1 | 134.0 | 137.8 | 157.0 | 157.3 | 154.2 | 137.4 | 150.9 | 150.9 | 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 |  |
| Ericsson | Y |  |
| Intel | Y |  |
| Samsung |  | For Msg 2, it should be clarified whether or not Rel-15 TBS scaling was applied for each simulation result. |
| InterDigital | Y | We have provide some update on our results. |
| FL4 | Majority of responses are fine with capturing the above link budget evaluation results to TR 38.875. One responses comments to clarify evaluation assumption for msg2.  For Msg2 results, some companies might have considered TBS scaling and some others have not. However, the assumption for TBS scaling is not available in the evaluation spreadsheet. The FL suggests the sourcing companies to clarify whether TBS scaling is used for Msg2.  Based on the responses, the FL makes the following proposal:  **[FL4] Proposal 3.4-1:**   * Capture the link budget evaluation results (indoor 28 GHz) in Table 3.4-1 to Table 3.4-3 to the Appendix of TR 38.875   + The tables will be further updated with potential updated coverage recovery evaluation results and a clarification of assumption for Msg2 | |
| vivo |  | For MSG2, we used MCS#0 with no TBS scaling |
| Qualcomm |  | We are fine with the FL updated proposal  For Msg2, no TBS scaling is used (4 RBs, MCS0, and TBS = 96) |
| Huawei, Hisilicon | N | We prefer to wait until proposal 1 is agreed.  For Msg2, no TBS scaling is assumed in our simulation. |
| Intel | Y | We simulate Msg2 with scaling factor 1/4 |
| Ericsson |  | Regarding TBS scaling for Msg2, we have provided results with and without TBS scaling. We suggest using results based on no TBS scaling as a baseline. TBS scaling can be considered as a coverage recovery technique for Msg2. |
| Samsung |  | No TBS scaling was used for Msg2. |
| ZTE |  | We are fine with the proposal.  For Msg.2, we use (3 RBs, MCS#0, TBS = 9 bytes) w/o TBS scaling. |
| InterDigital | Y | For Msg2, we used 3 RBs, MCS0, 72 bits. |

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. |
| Ericsson |  | We suggest clarifying (1) the meaning of the numbers in parentheses, and (2) how is the range computed (e.g., maximum-minimum).  “2Rx RedCap 100MHz BW” should be changed to “1Rx RedCap 100MHz BW” according to the caption of Table 3.4-2. |
| Samsung |  | For DL channels, big gaps between companies are observed. Before capturing the results, some clarification and analysis on the big gap are necessary. |

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

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

**Moderator’s observation**

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

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

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

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

***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 |
| Ericsson |  | P1: okay  P2: It should be clarified that the assumption is that a RedCap UE generates as much traffic as an eMBB UE. Then, in our view the degradation shown in the results is also due to the system load has increased when more and more RedCap UEs are added to the system. In our view, this is the main cause of the degradation.  P3: okay |
| Samsung |  | The comment in Q 4-1 should be addressed before agreeing it. |
| Huawei, Hisilicon |  | It is good to discuss traffic load and include its conclusion into the observation, e.g. the traffic contribution ratio of RedCap UEs, and the traffic load ratio of reference UE over RedCap UE. |

# 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. |
| Ericsson |  | In principle we are fine with P1.  The 2nd subbullet should be about lower “DM-RS” density.  For PUSCH data, the tradeoff between data rate and coverage can be considered. For example, HARQ retransmission and slot aggregation can be used for improving the coverage of PUSCH.  P2: no need to capture this now. |
| CATT |  | We do not think all solutions for UL coverage enhancements introduced in the Rel-17 CE SI could be reused. Considering that RedCap UE is aiming at low complexity/cost, simple methods with low implementation requirement and less specification impact are preferred. For example, we agree that repetition is recommended to Msg3 (P1 with sub-bullet1&3). |
| Samsung |  | Although likely, solutions listed in P1 are not agreed in the CE SI, it can be used “potentially introduced in the Rel-17 CE SI…”.  Not sure about SUL for RedCap and also L1 measurement payload reduction which seems related to PUCCH coverage recovery. In addition, SUL may not be mandatory for RedCap UE, and it may increase UE complexity. We should focus on the techniques can apply for most of UE with limited complexity. |
| LG |  | We are fine with main bullet in P1, but it would be better to discuss details after CE SI decision. |
| Convida Wireless |  | We agree in principle, but we have inquiry on the sub-bullet regarding Msg3 repetition. If the coverage of Msg3 needs to be compensated, the coverage of MsgA-PUSCH will require coverage enhancement as well. Please note that in AI 8.6.5, MsgA-PUSCH is one of the candidates for early UE identification. Therefore, we want to clarify whether MsgA-PUSCH should be included in the proposed baseline text for the TR or not. |
| Huawei, Hisilicon |  | We are fine with P1 and P2. For SUL, we would like to clarify that SUL does not increase UE supported BW and cost because there is no aggregated carrier bandwidth nor concurrent UL transmission between SUL carrier and NUL carrier, allowing UE hardware sharing among carriers, which is very different from CA. Additionally, in real markets, RedCap UEs will support multi bands naturally, SUL can fully utilize those UE hardware in those bands. |

## PDSCH coverage recovery

**Observation #1:**

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

**Observation #2:**

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

**Observation #3:**

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

**Observation #4:**

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

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

**Moderator’s observation**

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

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo |  | P3 requires RedCap UEs to support dynamic BWP switching with reduced delay, however, those are not assumed for reference UEs. This will definitely increase the RedCap UE complexity.  For Dynamic indication of the number of repetitions for PDSCH, it is already supported in Rel-16, such enhancements are not needed. |
| Futurewei |  | P1 is OK and may not be limited to small but may also include moderate. P2-P4 may depend on the observed CE SI. |
| Ericsson |  | We prefer to come back to this after we have a clearer view on coverage compensation needed for PDSCH. For example, P2 might not be needed if the need for PDSCH coverage compensation is not huge.  For PDSCH data, the tradeoff between data rate and coverage can be considered. (For example, HARQ retransmission and slot aggregation can be used for improving the coverage of PDSCH.) |
| CATT |  | Similar to the Question 5.1-1, simple methods with low implementation requirement and less specification impact are preferred. We think at least P1, P2 (1st bullet) are fine. |
| Samsung | Y |  |
| Convida Wireless |  | We agree in principle, but we have a question for clarification on whether PDSCH in FL’s proposals refers to PDSCH transmitted when UE is in RRC-connected mode or PDSCH transmitted when UE is in RRC-idle/inactive state, e.g. such RMSI-PDSCH and paging message. We note that there is a dedicate discussion for PDSCH of Msg2 and Msg4 in the next section. |
|  |  |  |

## Msg2 and Msg4 coverage recovery

**Observation #1:**

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

**Observation #2:**

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

**Observation #3:**

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

**Observation #4:**

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

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

**Moderator’s observation**

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

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo |  | For P3, it is not clear how to apply the enhancements to RedCap UEs, and gNB may not fully aware of UE capability before RRC connection. |
| Futurewei |  | P2 is OK and preferable, P1 is OK as existing techniques |
| Ericsson | Y |  |
| CATT |  | We think at least P1 is fine. |
| Samsung |  | We think P1 has already been supported by Rel-15 spec. and with P1, it may not need any other enhancements for Msg 2. In addition, some analysis is needed for the evaluation results of DL channels with a big gap between companies before drawing observations. |
| Convida Wireless | Y |  |
| Huawei, Hisilicon | N | We feel that existing TBS scaling is sufficient for Msg.2, don’t see the need to consider slot-aggregation or repetition.  It should be more careful to draw a feasible conclusion on some potential enhancement for Msg4 and Msg2. Because they may be optional UE feature and gNB has no sufficient knowledge whether a UE has supported it during initial access procedure.  More investigations are needed for P1-P3. |

## PDCCH coverage recovery

**Observation #1:**

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

**Observation #2:**

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

**Observation #3:**

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

**Observation #5:**

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

**Observation #6:**

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

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

**Moderator’s observation**

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

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo |  | Seems OK  It would be necessary to clarify that for repetition and/or increasing the CCE number for PDCCH transmission, one or more than more CORESETs may be used for PDCCH transmission. |
| Futurewei |  | Looks OK |
| Ericsson |  | P2: The meaning of “*Repetition and/or increasing the CCE number*” is not clear. Does it mean increasing the maximum supported AL in the CORESET configured for RedCap? |
| CATT |  | Generally OK. Some of the solutions may have impact on AI8.6.2 where PDCCH monitoring reduction is under discussion. May come back later. |
| Samsung | Y |  |
| LG |  | We are generally OK with P1 and P3.  Meanwhile, the meaning of candidate methods captured in sub-bullets of P2 are not clear. Also, pros and cons of various methods proposed by several companies have not been discussed in detail. So we prefer to discuss further on P2. |
| Convida Wireless |  | We agree in the principle, but we would like to clarify whether PDCCH in FL’s proposals includes RMSI-PDCCH and PDCCH that schedules Msg2/Msg4 or not. |
| Huawei, Hisilicon |  | For the perspective of coverage, it is still unclear that PDCCH enhancement is necessary.  To draw a conclusion to claim some PDCCH technique beneficial, we suggest to take into account the perspectives of network efficiency and capacity. Compact DCI can be considered to compensate the performance loss caused by UE RX antennas reduction. However, other PDCCH enhancement techniques seems not good for network efficiency and capacity, such as, repetition and/or increasing the CCE number for PDCCH transmission. Therefore, we don’t feel they are beneficial. |

## SSB and PRACH coverage recovery

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

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

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

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo |  | From the representative values captured in section 3, there is no issue identified for SSB and PRACH. |
| Futurewei |  | No coverage recovery needed |
| Ericsson |  | No need to capture any candidate recovery solutions for PRACH and SSB. These two channels do not need coverage compensation. |
| CATT |  | No need for SSB and PRACH coverage recovery. |
| Samsung |  | We don’t see a need of coverage recovery for SSB and PRACH |
| LG |  | No need to capture the candidate solutions. |
| Huawei, Hisilicon |  | No coverage recovery needed. |

# References

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

# Appendix –

## RAN1 agreements in 101e and 102

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

## RAN1 agreements in 103e

Agreements**:**

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