3GPP TSG-RAN WG1 Meeting #102-e Tdoc R1-20xxxxx

e-Meeting, August 17th – 28th, 2020

**Agenda Item: 8.6**

**Title: FL summary for RedCap evaluation templates**

**Source: Moderator (Ericsson, Apple, Qualcomm)**

**Document for: Discussion, Decision**

# 1 Introduction

This is the FL summary for Phase 1 in the following RAN1#102-e post-meeting email discussion:

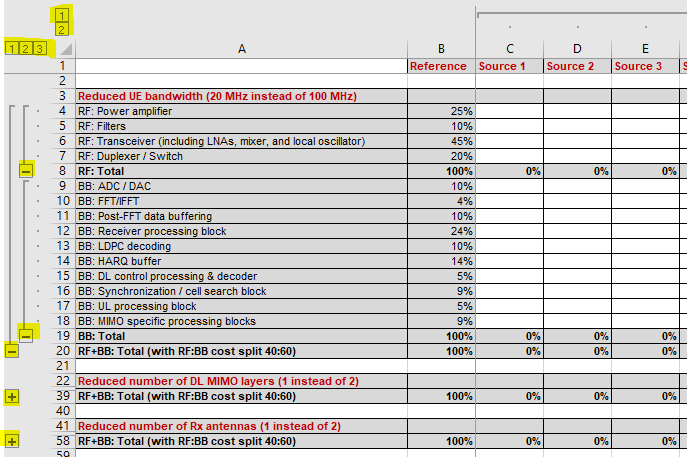
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| [102-e-Post-NR-RedCap-01] Email discussion/approval – Johan (Ericsson)/Hong (Apple)/Chao (Qualcomm)  Phase 1 (9/10-9/29): template for evaluations, including:   * cost reduction estimates * power saving estimates * coverage recovery and capacity impact simulation results   Phase 2 (9/30-10/21)   * Initial collection of the above evaluation results |

The discussion document and draft templates are stored in this working directory:

<https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Inbox/drafts/8.6/PostPhase1/>

# 2 Template for cost reduction evaluation

The first draft template is provided in [RedCapCostTemplate-v000.xlsx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Inbox/drafts/8.6/PostPhase1/RedCapCostTemplate/RedCapCostTemplate-v000.xlsx). The template for cost reduction evaluation has three tabs for **FR1 FDD**, **FR1 TDD** and **FR2 TDD**, respectively. On each tab, the details can be collapsed or expanded using the little buttons with numbers or plus/minus signs on them, highlighted in the figure below.



The individual cost reduction techniques are listed on the upper part of each tab and the combinations of multiple cost reduction techniques are listed further down on each tab. The combinations of multiple cost reduction techniques are preceded by the key word **Combination**. If all possible combinations were listed, there would be very many combinations to evaluate. Instead of listing all possible combinations, a small number of combinations is selected, where the intention is that the selected combinations are relevant, representative and can give insights into what cost reduction that can be expected also for many of the combinations that are not included in the list.

The cost breakdowns for the **Reference** devices are given in Column B on each tab, although the tilde (~) signs are excluded to facilitate mathematical operations on the data. Contributing companies can enter their cost estimates in one of the following columns (Column C and onwards). For simplicity, but somewhat differently compared to the approach used in some of the tables in TR 36.888, all numbers are ***cost estimates rather than cost reduction estimates***.

For example, looking at the figure above where the Reference cost for FFT/IFFT is 4% of the baseband (BB) cost, if a cost reduction technique would be estimated to result in 25% cost reduction in FFT/IFFT, then ***the cost estimate to enter on that row in the company’s column would not be 25% but instead be 75% of 4%, i.e. 3%***. This lower cost will then be reflected in the totals “BB: Total” and “RF+BB: Total”.

Below, the first question concerns collection of results for individual cost reduction techniques, and the second questions concerns combinations of multiple cost reduction techniques.

**Question 2-1: Can the spreadsheet be used to collect the cost reduction evaluation results for the *individual* cost reduction techniques? If not, what other aspects need to be added?**

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| --- | --- |
| **Company** | **Comments** |
| vivo | Fine with the template. Beyond the techniques that have been listed in the template, we wonder should companies be encouraged to provide analysis on other potential cost reduction techniques, e.g. reduced number of HARQ processes, and if so how to capture them into the table? |
| Ericsson | Yes |
| Samsung | Yes. |
| ZTE,Sanechips | It seems the template can only be used the record the numerical reduction figure but cannot be used to give a full picture of the cost reduction evaluation. For example coexistence, performance degradation and other impact on the system are missing. These are also the result from cost reduction evaluation but it seems the current template cannot reflect these aspects.  We suggest to include these aspect somewhere in the template, or we need to change the purpose of the spreadsheet to ‘collect the cost reduction estimate’. |
| FUTUREWEI | We should continue to do this as in 36.888. The values in the cells should continue to be the amount of reduction of that component. It is a lot more useful when discussing results to see that a company feels there is e.g. 75% reduction in HARQ buffer then seeing an entry of 3.5. Another benefit to do this is that the ‘total’ entries (RF, baseband, overall), other than the reference column, are directly the cost savings that we are used to seeing. It should be easy to modify the template, instead of a sum use a sumproduct with the reference column.  @vivo, the template should just have the techniques we agreed to study, others could be in company tdocs.  @zte, see your point and agree we need to collect but prefer this template to be just for cost estimates since we need to collect those anyway. |
| OPPO | Generally we are fine with the template.   1. We are wondering what is the difference between “Reduced number of DL MIMO layers” and “Reduced number of Rx antennas”. Does the former mean that the supported MIMO layer is smaller than the number of supported Rx, e.g., the UE support 2RX but only use one MIMO layer ? 2. We have the same question as vivo on how to handle other techniques, such as different DL/UL bandwidth combination. |
| Xiaomi | We have similar concern with vivo. For the UE bandwidth part, baseline of 20MHz was agreed. But some other values such as 40MHz were not precluded.  Although some other companies think this template should only include techniques agreed, we have different views. We think companies should be encouraged to provide analysis on potential cost reduction techniques, based on this analysis, we could have better understanding and then make the final decision on whether that potential technique should be agreed for study or not in next meeting. |
| Qualcomm | We think the template is a good reference for identifying the key enablers of UE cost saving. It is also useful for collecting the evaluation results corresponding to the individual techniques of cost reduction. In RAN1#101e and #102e meetings, we have discussed and agreed on some of the candidate techniques for cost reduction. In RAN1#103, we can further discuss other candidate techniques of cost reduction, which are covered by the template and within the scope of SID. |
| Huawei, HiSilicon | We have some comments on the template(s).   * For each ***individual*** cost reduction analysis, it may be clear to companies but would like to confirm, does it assume other techniques are not applied? For example, for “Reduced UE bandwidth (20 MHz instead of 100 MHz)”, the MIMO layer is assumed to be 2, the # of Rx is 2 and is FD mode, for FR1 FDD. * For each ***individual*** cost reduction analysis, is it clear to all that the ratio of RF:BB cost split as 40:60 is assumed for NR reference UE only? It becomes more complicated when need to be combined with other individual techniques. For example, only for Rx reduction to 1 without applying other cost reduction techniques, the ratio may be x:y other than 40:60; then this x:y should be used when combined with other techniques. * Propose to add row(s) for CSI computation relaxation for both FRs. |
| CATT | Yes |
| Spreadtrum | Generally, we are fine with the template.  Regarding the “relaxed UE processing capability”, we think reduced number of HARQ processes (or HARQ buffer size reduction) should be listed in the template, since we did not have any agreement or conclusion in the last RAN1 meeting to exclude this feature. As mentioned by vivo, if some companies provide analysis on it, how to capture them into the table. |
| Sierra Wireless | We would like to include a line item to comment if the specific technique has additional savings for multi-band devices (i.e. if the savings accumulate over multiple bands). |

**Question 2-2: Can the spreadsheet be used to collect the cost reduction evaluation results for the *combinations* of multiple cost reduction techniques? If not, what other aspects need to be added?**

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| --- | --- |
| **Company** | **Comments** |
| Ericsson | Yes. Regarding combinations of techniques, we can start with those currently listed. |
| Samsung | We suggest to focus on cost break down of each separated techniques firstly, to conclude the cost saving for each technique. And then discuss the potential combinations and the cost saving later, which can exclude some techniques with limited cost saving and reduce the combinations. |
| ZTE,Sanechips | See answer to 2-1. |
| FUTUREWEI | Agree with Samsung. Combinations could be in company tdocs (if desired, for example, to show that some technique has little gain and even less when on top of BW and/or antenna reduction). Then we can decide and collect a few combinations in the meeting. |
| OPPO | Share same view as Samsung. We can firstly focus on the evaluation on each separated techniques. |
| Xiaomi | Agree with Samsung. At current stage, cost saving analysis for the individual technique should be prioritized and then we can go further to collect results for some potential combinations |
| Qualcomm | Yes |
| Huawei, HiSilicon | We are Ok with Samsung suggestion and regarding the ***combinations*** of multiple cost reduction techniques, we   * For FR1, encourage to add the combination case for 2 layers and 1 Rx as one interest case. With the understanding that they represent the cost parts of BB and RF respectively, the implementation of MIMO layers in BB/chipset and Rxs in RF frontend should be able to be different. Thus, in addition to the case of 1 layer with 1/2 Rx, the implementation and corresponding analysis for 2 MIMO layers in BB/chipset with 1/2 Rx in RF should also be considered. This is particularly some of the interested device forms in LTE era, i.e. the so-called LTE Cat 4bis in real market. This approach also minimizes the number of types of different chipset designs to avoid market segments (can be one), thus could be more cost reduction in a long term. * Probably echoing the comments from a few other comapnies that even though results for each individual cost reduction techniques is provided, the different combination cases do not seem to be able to be directly obtained from the sum of the results based on individual cost reduction. Thus we wonder how to be representative and insightful, and how the unselected combination cases by the current template(s) would be taken into account, compared with the selected ones. |
| CATT | In our view, the breakdown of each individual technique should be focus. When studying the cost of RedCap UE, it is more desired to find out which techniques contribute most to the cost reduction, and then to guide the potential standardization work in the future. Combinations of different techniques serve the same goal but require more discussion time. But companies can still optionally provide the cost estimation of combinations, especially if contradictory case is found, i.e. the cost reduction from different techniques cannot be superposed. |
| Spreadtrum | We share the same view with Samsung that we need to focus on cost break down of each separated techniques firstly. |

# 3 Template for power saving evaluation

The first draft template is provided in [RedCapPowerTemplate-v000.xlsx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Inbox/drafts/8.6/PostPhase1/RedCapPowerTemplate/RedCapPowerTemplate-v000.xlsx). In current TR 38.840, TDD was assumed for power saving evaluation in FR1/FR2. It can be reused for Redcap study item to simplify the power reduction evaluation for reduced number of blind decoding and CCEs. Regarding the performance metrics, at least power saving gain and the corresponding PDCCH block rate should be evaluated. With these considerations in mind, three tabs were created in template as follows:

* **Tab-3:** Power saving gain – FR1, TDD, 1 RX
* **Tab-4:** Power saving gain – FR1, TDD, 2 RX
* **Tab-5:** Power saving gain – FR2, TDD, 1 RX
* **Tab-6:** Power saving gain – FR2, TDD, 2 RX
* **Tab-7:** PDCCH blocking rate evaluations

For the Tab-7, i.e. PDCCH blocking rate, “approximately” was added in front of “25%” and “50%”. The reason is that since the BD limit for FR1 (30 kHz SCS) is 36, 25% reduction in BDs is 27. However, if the UE is monitoring only 2 DCI sizes, then we will not be able to get 27 (no. of BDs = no. of DCI sizes \* total no. of PDCCH candidates for all ALs). Similarly, “approximately” is added in front of “50%” for the case where three or four DCI format sizes are monitored by UE.

Still on Tab-7, there are a few optional assumptions e.g. 3-symbols CORESET configuration, 2 slots delay toleration. The template was organized as follows to collect results:

* The first table in Tab-7 is for the combination of the non-optional assumptions, where there is no need to describe anything in the ’Comments’ column
* The second table is for all combinations that include some optional assumptions, where companies need to describe what settings they have used in the Comments column.

**Question 3-1: Can the power saving gain tabs in the template (i.e. Tab-3/4/5/6/7) be used to collect the evaluation results? If not, what other aspects need to be added?**

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| **Company** | **Comments** |
| vivo | Yes, the template can be used for collection evaluation results. But we wonder what TDD DL/UL configuration is expected to be used for power evaluation? Should we use the same assumption as for Capacity evaluation, i.e. the following   |  |  |  | | --- | --- | --- | | 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) | |
| Ericsson | Yes. However, the power consumption models for PUCCH/PUSCH need to be added. Our proposal is to reuse TR38.840 models as below.   |  |  |  |  | | --- | --- | --- | --- | | Power State | Characteristics | Relative Power | | | FR1 | FR2 | | UL | Long PUCCH or PUSCH. | 250 (0 dBm)  700 (23 dBm) | 350 |   In our view, the time percentage values for different power states for different traffic models are needed for performing the power saving evaluations. The time percentages are needed to compute the contribution of each state to the overall power consumption. Since there are no agreements on the time percentages, we suggest companies declare the values. So, we suggest adding an additional tab to capture the time percentage values. |
| Samsung | Yes.  For Tab-4 and Tab- 6, we suggest to consider system bandwidth of 100MHz only as we don’t have power model of system bandwidth of 50MHz. |
| ZTE,Sanechips | Regarding the issue of UL model, if long PUCCH is considered, then short PUCCH also should be considered. Corresponding agreement from CE SI can be reused if needed. Additionally, since the uplink transmission is not modeled, maybe only the PUCCH can be considered, while PUSCH for UL can be removed.  Secondly, the performance reduction by limiting BD is effected by the order of AL detected by UE. For example, if the BD limit is 7, set AL=1 with candidates 6 and AL=2 with candidates 8, the performance would be different when UE detect the PDCCH with the starting AL=1 or AL=2. In order to obtain the comparable results, the model of this may need to be unified.  Thirdly, BD reduction has an impact on the PDCCH power consumption in the ‘PDCCH+PDSCH’ state. In order to obtain the accurate and overall evaluation results, BD reduction benefit for the ‘PDCCH+PDSCH’ state should be modelled. As mentioned in RAN1 102e-meeting, the PDCCH+PDSCH power consumption contains two parts: PDCCH part and PDSCH part. For power scaling by PDCCH candidate reduction for PDCCH+PDSCH:  P(X) = (1-*a*)PPDCCH+PDSCH+*a*\*PPDCCH+PDSCH\*X  where:   * PPDCCH+PDSCH is the PDCCH+PDSCH power and PPDSCH is the PDSCH-only power. * *a*\*PPDCCH+PDSCH\*X for PDCCH contribution part in PDCCH+PDSCH * (1-*a*)PPDCCH+PDSCH for PDSCH contribution part in PDCCH+PDSCH * where X is the ratio of P(α) to the Pt * *a* means the PDCCH relative power consumption(PPDCCH ) proportion in the whole PDCCH+PDSCH power consumption(PPDCCH+PDSCH)   We suggest to add one sub question to further clarify this issue for the simulation:  Question 3-1a : **Can the power saving model for PDCCH part in ‘PDCCH+PDSCH’ state be used to collect the evaluation results? If not, what other aspects need to be added?** |
| FUTUREWEI | Yes |
| OPPO | Yes.  Regarding the TDD UL/DL configuration, we would like clarify this could be report by companies. In power saving SI, the UL/DL configuration was not specified and company can have their assumption. E.g it can assume dynamic TDD and the PDCCH may be monitored in every slot. We may not have to go into the details that which band will use which UL/DL configuration.  Regarding the time percentage, we guess this is what the simulation should output as intermediate values but the final results is the power saving gain. |
| Qualcomm | Yes |
| Huawei, HiSilicon | Yes with some modifications.   1. Besides the performance metrics in the template, we suggest to add absolute numbers for power consumption in power unit for each cases in Tab-3/4/5/6. 2. It should be also clarified that the same baseline and evaluation assumptions regarding the number of DCI sizes per PDCCH candidates, number of candidates per each AL and AL distribution should be assumed for the PDCCH blocking rates in Table 7 and the power saving results in Tab-3/4/5/6. 3. In the tabs for power saving gain, reduced number of BDs is considered to save power. However, according to the discussions and contributions in RAN1 #102-e, there are two ways to reduce the number of BDs, one is to reduce the number of PDCCH candidates, the other one is to reduce DCI size budget. Although the same number of BDs is reduced, different scheme results in different power saving gain, because different scheme have different scheduling latency which has impact on the length of Active Time. It is proposed to clarify how the BD is reduced in the comment column when the results are reported. |
| CATT | Yes.  In addition, we think companies can still provide additional assumptions/descriptions/clarifications in the ‘Comments’ column even for the non-optional cases in any Tabs, if necessary. |
| Spreadtrum | Yes  For Tab-5 and Tab- 6, we share the same view with Samsung. |

**Question 3-2: Can the PDCCH blocking rate tab in the template be used to collect the evaluation results? If not, what other aspects need to be added?**

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| **Company** | **Comments** |
| vivo | Yes, the template can be used in general.  We would like to clarify that “Number of users (e.g., 10)” is the number of simultaneously scheduled UEs in a slot. This is the key factor for the PDCCH blocking evaluation, we think companies should provide justification to the “number of users” they selected by SLS evaluation, e.g. what deployment scenario, traffic model, resource utilization, etc, so that observation of blocking issues can be drawn based on realistic assumptions. |
| Ericsson | Yes |
| Samsung | Yes.  For the assumption about number of users in Tab-7, we suggest to consider multiple values, e.g. 1 to 10, instead of a single value, e.g. 10. Companies can provide multiple PDCCH blocking rates corresponding to a range of values for the number of users. |
| ZTE,Sanechips | Yes. The assumption for UE number and AL distribution can be used simple and effective for the blocking rate simulation. Using the full blown SLS for this is not necessary and may cause other problems. For example, the resources for PDCCH may be used by PDSCH in the SLS. But this issue is not related to ‘PDCCH blocking caused by BD limiting’. Therefore we suggest not using SLS here. |
| FUTUREWEI | Yes. Agree with Samsung that it would be valuable to agree on a set of number of UEs to use for simulation |
| OPPO | The text outside of bracket is OK. However, the e.g parts may be misleading. For the AL distribution, we do not think the one is represented.  The number of user should be clarified. If we assume it is the number of UE been simultaneously scheduled, then much smaller than 10 is a reasonable number. An alternative one is, the system schedule the band with x user and the scheduling of user is based on the traffic models.  In addition the CORESET BW is assumed for the entire capability band of UE. We can add that description in CORESET. |
| Qualcomm | Yes.  It is desirable for companies to align on the range of parameters assumed for evaluation, such as the number of UEs, the number of DCI sizes, the number of candidates for each AL and etc. If companies arbitrarily choose the simulation assumptions, the results may diverge and it will be challenging to draw meaningful conclusions. |
| Huawei, HiSilicon | Yes with some modifications.   1. The RX number will impact the PDCCH demodulation performance and accordingly impacts the PDCCH blocking rate. Therefore, similarly as that for power consumption results in Tab 3/4/5/6, PDCCH blocking rates should be also provided for both 1RX and 2RX, respectively. This is also beneficial to align with the analysis for the power saving gain in Tab 3-6 wherein both 1 RX and 2 RX are considered. 2. In our view the provided configurations of AL distributions (Configuration 1~4) assume the 2Rx UE reception. We propose to consider one more configuration for 1Rx reception case. (See the comments on Question 3-3). 3. Additionally, for the first table in Tab-7 where the combination of the non-optional assumptions is assumed, in the example, the number of PDCCH candidate for AL = 16 should be 1 other than 2, considering 2 symbols and 30KHz/20MHz CORESET cannot have two AL16 candidates. Alghough it is an example, it would be better to correct it as following:   *Number of candidates for each AL for the reference case, i.e., with no reduction in BD limit (e.g., [6 6 2 2 1] for AL = [1 2 4 8 16]).* |
| CATT | Yes. |
| Spreadtrum | Yes |

In the RAN1#102-e meeting, PDCCH blocking rate evaluation was discussed and consensus was reached on a few parameters including SCS/BW, CORESET duration, delay toleration. However, company views were still not converged on some important parameters e.g. aggregation level distributions and number of candidates for each AL. It therefore was agreed to leave for company report. However, the assumption should not be too broad to make the results incomparable. To produce comparable evaluation results, it was further recommended by feature leader to limit the AL distribution of [1,2,4,8,16] as one of the following:

* **Configuration 1:** [0.5, 0.4, 0.05, 0.03, 0.02], assuming majority of the UEs are in is good coverage
* **Configuration 2:** [0.1, 0.2, 0.4, 0.2, 0.1]: Majority of the UEs are in medium coverage
* **Configuration 3:** [0.05, 0.05, 0.2, 0.3, 0.4]: Majority of the UEs are in poor coverage
* **Configuration 4:** [0.2, 0.2, 0.2, 0.2, 0.2]: Uniform distribution

**Question 3-3: Can we limit the AL distributions to be one of the four configurations listed above? If not, what other configurations need to be added? It should be noted that it is important to minimize the configurations to ensure the comparable results.**

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| **Company** | **Comments** |
| vivo | This is highly dependent on the simulation assumptions, including SINR distribution, DCI payload size, etc. We observed there can be cases with even better AL distribution than configuration #1. If there is a strong need to align the AL distribution, we would like to add the following configuration to represent such cases  Configuration #5: [0.7, 0.2, 0.05, 0.03, 0.02] |
| Ericsson | Yes. It would be good to be able to align results between companies. Thus, we would suggest we all evaluate Configuration 4 for alignment purpose. Then, additional configurations on the list can be evaluated based on each company’s preference. |
| Samsung | Yes. |
| ZTE,Sanechips | Yes |
| FUTUREWEI | Yes. Since the distribution is heavily scenario dependent, we should go with a medium distribution (configuration 2 or 4). We prefer 2 since 4 is an artificial one. |
| OPPO | We would prefer highest probability for the AL=2. For AL=16, it is too high for 0.2, which means very poor coverage can happen in same probability as others.  We suggest: [0.4, 0.5, 0.05, 0.03, 0.02], if a common assumption can be agreeable. |
| Qualcomm | Yes.  Another option is to take one distribution with smaller AL (i.e., configuration 1) and another distribution with larger AL (i.e., configuration 3). In reality, it may be not typical to have a uniform distribution like configuration 4. |
| Huawei, HiSilicon | Partially yes and another configuration for 1Rx UE should be added.   1. To ensure the comparable results, we are fine to limit AL distribution to be one of the four configurations. When the DCI size is assumed to be 64bits (including CRC), it is fine to use Configuration 1 for evaluation. 2. Also, it should be clarified that the above configuration 1~4 are for evaluations with 2 RX reception. As replied to the previous question, we suggest to add configuration 5 for PDCCH blocking rate evaluation assuming 1 RX reception. For example, Configuration 5: [0.3, 0.5, 0.10, 0.06, 0.04]: 64bits DCI size (including CRC) with 1Rx reception. |
| CATT | Yes.  And according to our observation, AL16 is rarely applied in any of the scenarios, i.e. less than 10%. Thus Configuration 1 or 2 is preferred. |
| Spreadtrum | Yes |

# 4 Template for coverage recovery evaluation

The first draft template is provided in [RedCapCoverageTemplate-Urban2.6GHz-v000.xlsx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Inbox/drafts/8.6/PostPhase1/RedCapCoverageTemplate/RedCapCoverageTemplate-Urban2.6GHz-v000.xlsx). The first two tabs (one for the reference UE and the other for RedCap UE) describe where the assumptions come from and the following tabs are used to collect results for the concerned channel and message. On the tabs for collecting results, the first column contains the reference UE case, followed by one or two columns for the RedCap case. One spreadsheet only concerns one scenario, and there would be four spreadsheets for the concerned 4 scenarios, e.g. Urban-2.6GHz, Urban-4GHz, Rural-700MHz and Indoor-28GHz. Currently, only the spreadsheet for Urban-2.6GHz is provided. If it is considered useful, additional spreadsheets would be created for the other three scenarios,

**Question 4-1: Can the spreadsheets be used to collect the coverage recovery evaluation results? If not, what other aspects need to be added?**

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| **Company** | **Comments** |
| vivo | Generally fine with the spreadsheets.  However, since there are still some of the evaluation assumptions not stable in CE SI, which are discussing in [102-e-Post-NR-CovEnh-01]. Following aspects may need to be further updated to align with the templates to be provided by CE SI, summarized as follows.  1, The definition on MIL may be changed to include (12) /connector/combiner/body losses (Rx side) in [102-e-Post-NR-CovEnh-01], we suggest to align with the template provided in CE SI.  2, Besides, in [102-e-Post-NR-CovEnh-01], the UE antenna array gain components are still discussing, which is more complicated for FR2, we suggest to align with the agreements made in CE SI after new agreements are made, especially for FR2. |
| Ericsson | Yes. We agree with Vivo that updates on link budget template may be considered later on, motivated by future CE SI agreements. |
| Samsung | Yes in principle. We also prefer the updated spreadsheet in order to reflect outcomes from on-going email discussions in CE SI. |
| ZTE,Sanechips | 1. For DL we suggest to introduce power spectrum density (for calculation of Tx power), and reuse the corresponding agreement from CE SI :  * For 2.6 GHz frequency,   + For urban scenario, PSD is 33 dBm/MHz * For 700MHz,   + For rural scenario, PSD is 36 dBm/MHz * For 28GHz,   + For indoor scenario, PSD is 36 dBm/MHz  1. We share some similar view with VIVO , actually , Δ1 and Δ2 are not considered in the antenna array gain calculation, this is different from CE SI’s agreement. Based on previous agreement ‘For RedCap coverage analysis, the agreements in the Rel-17 CE SI regarding link budget template and antenna array gain are reused’, We suggest to introduce Δ1 and Δ2. |
| FUTUREWEI | Yes, not precluding any updates in the future |
| OPPO | Generally we are fine with the spreadsheets. The discussion on some items in the sheets are ongoing in CE SI. They may be further updated to align with new agreements made in CE SI later. |
| Xiaomi | Generally OK. We also think further updated based on the outcome of the CE SI discussion should be reflected. |
| Qualcomm | Yes.  We think it would be helpful if the FL could provide the spreadsheet/templates for 28 GHz, indoor scenario as well. |
| Huawei, HiSilicon | OK if the proposed changes in Q4-2 and Q4-3 are accepted. |
| CATT | Yes. The template can be further updated based on the conclusion from CE SI. |

In the RAN1#102-e meeting, it was agreed to reuse the link budget template agreed in the Rel-17 CE SI for coverage recovery evaluation. The link budget template for the Rel-17 CE SI is based on IMT-2020 self-evaluation with necessary revisions including adding/removing/revising/simplifying some parameters. However, the update of the link budget template has not started in the Rel-17 CE SI, and thus it is not desirable to await the agreement in the CE SI before proceeding with coverage analysis for RedCap.

In the template for coverage recovery evaluation, an adapted version of the IMT-2020 self-evaluation template is used, where items related to the “Maximum range” have been deleted. In addition, four rows (i.e. row(40a), (40b), (41a) and (41b)) are added for supporting the calculation of the “Maximum coupling loss”.

**Question 4-2: Can the proposed link budget template be used to perform the coverage analysis? If not, what modifications are needed?**

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| **Company** | **Comments** |
| vivo | For antenna gain and array gain, in CE antenna gain component 3 and component 4 are merged to one row, according to agreements made in RAN1#102e, and components 2 is separated from component 3. While in the proposed link budget template, the component 2 and component 3 are merged in one row, i.e. (5), and component 4 is in another row, i.e., (4). we suggest to align with the agreements made in CE SI.  Agreements:  Further clarify the agreement on antenna gain and antenna gain components including antenna gain correction factors as follows:   * For both TDL option 1 (table A below) and TDL option 2 & CDL (table B below)   + The gain of antenna gain component 1 is included in LLS results   + The gain of antenna gain component 2 is included in link budget template     - The gain is expressed by 10 \* log 10( N/k ) - Δ1     - For TDL option 2 & CDL, the gain is 0 dB   + The gain of antenna gain component 3 is included in link budget template   + The gain of antenna gain component 4 is included in link budget template     - The gain of antenna gain components 3 and 4 is expressed by Antenna Element Gain + 10 \* log 10( M/N ) -Δ2     - For Tx, One row is used represent the gain of antenna gain component 3 + 4, i.e. row No. (4)     - For Rx, One row is used represent the gain of antenna gain component 3 + 4, i.e. row No. (11)     - Note: more appropriate name or explanation will be added to row No.(4) and (11). Details can be discussed when the link budget template is updated. |
| Ericsson | Yes. Although SSB and PRACH are not explicitly included in the link budget evaluation agreements, they are not excluded either. Although we do not expect these channels to become the coverage bottleneck, we will provide evaluation results for these channels for completeness.  Regarding Vivo’s comment on antenna gain components, we see the main point is that antenna gain component 3 should be included in lines (4) and (11), rather than in lines (5) and (11b) based on the CE SI agreement. I guess this revision will not change the final link budget results. We are fine with either the FL proposal or Vivo’s suggestion. |
| Samsung | We are OK with Vivo's suggestion. In principle, we think it would be good to align assumptions between RedCap and CE including antenna gain/array gain except Redcap specific ones. |
| ZTE,Sanechips | We are OK if the issues raised in 4-1 are solved. |
| FUTUREWEI | Similar to 4-1, OK without precluding any updates if needed. |
| OPPO | Yes. We can use this proposed link budget template as starting point. The alignments between RedCap and CE are also can be done once CE is concluded. |
| Xiaomi | OK with vivo’s suggestion. |
| Qualcomm | We are fine with the link budget template.  In FR1, there is no need to include SSB and PRACH in the evaluation, since 20 MHz is agreed as the baseline UE BW for initial access  For FR2, companies can evaluate SSB and PRACH as well, to examine the performance impacts of different UE BW capability (50 vs 100 MHz). |
| Huawei, HiSilicon | No.  **Change1:** The scenario “O-to-I” should be declared for all the PHY channels.  Reason: The penetration loss in MPL calculation is related to the scenario “O-to-I” or “O-to-O”, so we suggest declaring the scenario “O-to-I”, e.g.    **Change2:** row(1bis) should be modified to “Number of transmit chains”  row(10bis) should be modified to “Number of receive chains”  Reason: For gNB, 64TxRUs have 64 transmit antenna ports, in LLS, the number of transmit chains is 4, we suggest changing antenna ports to chains as agreed in CE SI, in order to avoid confusion, e.g., |
| CATT | We are OK with either the FL’s proposal or Vivo’s comment. |

In the proposed link budget template, some parameters have been assigned with specific values which are based on the CE SI agreements. It is assumed that company is not required to change the values for these parameters. The parameters that company can declare the values are highlight with orange color.

**Question 4-3: Are the proposed values for the fixed parameters acceptable? If not, please provide the parameters that are needed to be changed and the proposed values?**

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| **Company** | **Comments** |
| vivo | For interference density at receiver, we suggest to use the parameter provided by IMT-2020 as a baseline, and companies can report the value, instead of fixed to ‘-999’dBm.  For (1bis) Number of transmit antenna ports and (10bis) Number of receive antenna ports at gNB, 2 or 4 can be up to companies report based on the agreements in RAN1#102e, instead of fixed to 4.  For the following parameters, although the exact values can be reported by companies, we suggest to revise some values to align with the values that are considered as starting point in IMT-2020 or agreed in CE SI, in the initial templates for guidance.  According to the Notes in the template, the value for shadow fading margin and penetration margin used in IMT-2020 can be considered as a starting point. However, the value provided in the template, i.e. (24), (25a), (25b) and (27), is not aligned with the values used in IMT-2020. We suggest to make the IMT-2020 value as the default value in the template, while companies can report a different value. The values used in IMT-2020(Channel Model A) are provided as follows.   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | **DL Control** | **DL Data** | **UL Control** | **UL Data** | | (24) Lognormal shadow fading std deviation (dB) | ~~6.00~~  7.00 | ~~6.00~~  7.00 | ~~6.00~~  7.00 | ~~6.00~~  7.00 | | (25a) Shadow fading margin for control channel (function of the cell area reliability and (24)) (dB) | ~~8.00~~  7.56 | - | ~~8.00~~  7.56 | - | | (25b) Shadow fading margin for data channel (function of the cell area reliability and (24)) (dB) | - | ~~5.00~~  4.48 | - | ~~5.00~~  4.48 | | (26) BS selection/macro-diversity gain (dB) | 0.00 | 0.00 | 0.00 | 0.00 | | (27) Penetration margin (dB) | ~~15.00~~  26.25 | ~~15.00~~  26.25 | ~~15.00~~  26.25 | ~~15.00~~  26.25 | | (28) Other gains (dB) (if any please specify) | 0.00 | 0.00 | 0.00 | 0.00 |   For MSG3, the number of PRBs is 2 based on agreements in RAN1#101, we suggest to use 2RBs instead of 30RBs as the default value in the template. |
| Ericsson | Yes.  Regarding the number of gNB Tx/Rx chains, our suggestion is that we use 4 for 2.6 GHz, and 2 for 700 MHz so that we can easily compare results.  We are fine with Vivo’s proposed values for lines (24), (25a), (25b) and (27). |
| Samsung | We agree with Vivo that the values in IMT-2020 or agreed in CE SI should be considered as starting point in the template. |
| ZTE,Sanechips | It should be clarified that for limiting channel selection MIL should be prioritized. Also, some of the parameter value can reuse result in CE SI once agreement is reached there. |
| FUTUREWEI | Agree with Vivo’s proposal, better to align with IMT 2020 in terms of default values |
| OPPO | Yes. In CE SI, it is proposing now that the items (25a,b), (26), (27) and (28) are left to companies’ report, which includes the values for IMT-2020 self evaluation and/or using 0 dB. We could finnally ok with the values used in IMT-2020. However, to be aligned with CE SI, we can wait for the outcomes of CE SI before updating these items. Thus, it may not be concluded now. |
| Xiaomi | We agree with vivo and Samsung. We also think it is better to align with the values in IMT-2020 or use the same value with that in CE SI. |
| Qualcomm | Yes.  For (1bis) number of transmit antenna ports and (10bis) number of receive antenna ports, we prefer to fix the values for evaluation, e.g. 2 for 700MHz and 4 for 2.6GHz to easy comparison.  For (24), (25a), (25b) and (27), we are okay with vivo’s proposal to use the IMT-2020 values as a starting point. |
| Huawei, HiSilicon | No.  We are fine with Vivo’s proposed values for row (24), (25a), (25b).  **Change1:** a note is added that row (27) penetration margin (dB) should be adjusted according to simulated carrier frequency. Remove 15dB from the row.  Reason: In ITU-2020 self-evaluation, 26.25dB and 12.50dB are separately considered for 4GHz DU-eMBB and 700MHz Rural-eMBB. So we suggest following values:   * 4GHz DU-eMBB: 26.25; * 2.6GHz DU-eMBB: 23.25; * 2.0GHz DU-eMBB: 22.25; * 700MHz DU-eMBB: 16.25; * 700MHz DU-Rural: 12.50; |
| CATT | OK to align the template with IMT-2020.  Regarding the number of gNB Tx/Rx chains, we think it can be be up to company’s report. Either 2 or 4 should be fine.  Regarding the Msg3 bandwidth , agree with Vivo that occupied channel bandwidth should be modified to 2PRB (from 10800000Hz to 720000Hz) |

For post processing, there could be the following two alternatives.

* **Alt. 1:** Take the average or midpoint for the parameters that the company declare the values and then plug the average value into a link budget.
* **Alt. 2:** Take the average or midpoint for the calculated MIL/MCL/MPL without repeating the link budget calculation.

Alt. 1 may require a common assumption for link level evaluation, e.g. number of Tx chains, #PRBs, etc, while Alt. 2 is more flexible to support different link level evaluation assumptions, but the problem with Alt. 2 is that only the values of the MIL/MCL/MPL can be copied and paste into the TR instead of the whole link budget table.

**Question 4-4: For post processing, can we down-select from the above two alternatives? If not, please provide the other alternative for consideration. If yes, please provide your view on which alternative is preferred.**

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| **Company** | **Comments** |
| vivo | Neither Alt.1 or Alt.2  The MIL/MPL is calculated by quite a lot of parameters, such as antenna/array gain, MCS and PRB, number of repetitions, etc. The average or midpoint for parameters and MIL/MCL/MPL is only applicable when all the parameters are aligned among companies.  Hence, we suggest to capture the parameters and MIL/MCL/MPL provided by each company in to TR. And the bottleneck channel can also be reported by individual companies rather than deterimed based on average or midpoint of the MCL/MIL/MPL. |
| Ericsson | Perhaps this does not need to be settled now. We can discuss post processing alternatives when we have collected all the results. |
| Samsung | Vivo’s suggestion seems reasonable. However, no need to down-select one, right now. |
| ZTE,Sanechips | It is very hard to understand the rational for ALT1. The averaging cannot be used without careful consideration. The midpoint for lots of parameter doesn’t make any sense and list the average will cause confusion. For example, the mapping between PRB number and required SNR are not linear, taking the average of both will give a distorted relationship.  We are OK with ALT2, we can also include individual source beside the average. |
| FUTUREWEI | Need more time for this. In general both alternatives don’t seem reasonable. |
| OPPO | No need to decide now but this discussion could be a reminder. This issue can be further determined after the initial LLS results of companies are available. |
| Xiaomi | We think more discussion is needed and Vivo’s suggestion is acceptable for us. |
| Qualcomm | We think it is necessary to agree on some principles for post processing and analyzing the evaluation results, in order to determine the bottleneck channels for coverage recovery.  We are okay with Alt. 2. |
| Huawei, HiSilicon | **Neither Alt.1 or Alt.2**  We don’t feel Alt.1 is reasonable, some parameters in link budget are correlated. For example, occupied channel bandwidth reported by different companies may be different, the average/midpoint of the reported values may correspond to the average/midpoint of the reported MCS and the required SINR.Taking TR 37.910 as a precedent, link budget tables can be an attachment of the TR.  Similar view as Vivo, we prefer to capture into TR all parameters and MIL/MCL/MPL from each company source. Because several parameters are up to company report, maybe a range of MIL/MCL/MPL is better to average/midpoint. We are open to discuss it. |
| CATT | May be discussed latter.  For Alt.1, not sure averaging is reasonable for all the characters, since some mapping relationship is not linear. For Alt.2, we are generally OK, but we think not only the final result but also some critical intermediate variables can be captured, e.g. required SINR. |

# 5 Template for capacity impact evaluation

The first draft template is provided in [RedCapCapacityTemplate-v000.xlsx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Inbox/drafts/8.6/PostPhase1/RedCapCapacityTemplate/RedCapCapacityTemplate-v000.xlsx). Six tabs are created for collecting the results for the concerned scenarios each with two tabs for UL and DL, respectively. On each tab, there are 8 tables, where four are used for the non-full buffer traffic and the other four are used for the optional full buffer traffic for different ratios of RedCap UEs in the network.

For the non-full buffer traffic, the performance metric is based on 5% and 50% UPT, and company is required to report the value of resource utilization (RU) for low and medium loading. An SE row is also included in the non-full-buffer table, where we use the “bits/RE” as the performance metric. Note that “bits/RE” has been used as a SE metric in previous 3GPP SI (see e.g. TR 38.802).

For the full buffer traffic, the performance metric is based on the cell average SE.

**Question 5-1: Can the spreadsheet be used to collect the capacity impact evaluation results? If not, what other aspects need to be added?**

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| **Company** | **Comments** |
| vivo | We have following question and comments to the current table.   1. We think it would be reasonable to collect the results (e.g. UPT, SE) separately for reference UEs and the RedCap UEs, since the aim is to look at the performance impact to reference UE due to the presence of RedCap UEs in the cell. We wonder if this is also the understanding from moderator, and if so, the table would need to be updated. 2. We think it may be difficult to perfectly match the exact loading ratio, e.g. 30%, or 50%, so company report on their load ration would be needed. 3. And we do not think taking Avg. or Med. among different companies are very meaningful, the most important information is how much capacity difference for the system with different percentage of RedCap UEs (including the case without RedCap UEs) |
| Ericsson | The template is good. But a few comments from our side.   1. Should the loading level be determined based on the limiting link (either DL or UL)? For example, if the UL is the limiting link (i.e. it has higher RU than the DL), we then load the network to the medium loading level so that the UL reaches 50% RU. We then report the actual RUs for DL and UL, respectively, in the tables. 2. We assume the UPT statistics include both the eMBB and RedCap UEs. But in this case, the drop in UPT as the percentage of RedCap UEs in the network increases might be simply due to more RedCap UEs being included in the 5% UPT due to its lower UPT performance resulting from BW/antenna/efficiency reduction. This reduction is not the same as capacity reduction. So it might be good to report eMBB UPT statistics additionally, which is directly coupled to eMBB capacity reduction. 3. It is not clear what RedCap complexity reduction combination is considered. We propose as a start we can assume the most ambitious cost reduction combination, e.g. 20 MHz, 1 layer, 1 Rx, DL 64QAM, and UL 16QAM in FR1 FDD. 4. According to the SID, we need to evaluate the network capacity and spectral efficiency impact from coverage recovery. There are no agreements on what coverage recovery solutions can be considered for RedCap UEs. We suggest that companies can declare which coverage recovery solutions are assumed in SLS. |
| ZTE,Sanechips | It is better to clarify the purpose of the effort. In the SID, there are two requirement of capacity/spectral efficiency study, one is under the sub-bullet of UE complexity reduction, the other is under coverage recovery sub-bullet.  So it should be clear two sets of result should be provided, the first sets of result is to evaluation the impact of UE complexity reduction only, and the second sets of result is to evaluate the coverage recovery. |
| Qualcomm | The template looks good to us.  It is desirable to collect the performance metrics (e.g. UPT, SE) separately for reference (eMBB) UEs and RedCap UEs.  In addition, the combined metrics can also be collected for all UEs (eMBB + RedCap). |
| Huawei, HiSilicon | No.  We think two parameters are missing in the spreadsheet, traffic model of busty buffer and number of UE Rx antenna for DL evaluation.  For traffic model of busty buffer, we suggest that FTP model 3 should be mandatory for RedCap UEs and legacy UEs, IM traffic model can be optional because as commented last meeting, IM traffic model cannot provide a ratio of traffic data rate larger than 1:50 between REDCAP UEs and legacy UEs.  For evaluation methodology with burst buffer, based on online/offline discussions, in our understanding, there seems to be two methods on the table:  **Option1**: Given percentage of RedCap UEs and reference UEs, traffic model for two types of UEs, the total UE number becomes the tuning variable to achieve the target RU. If IM traffic model is used for RedCap UEs, the simulated total UE number will become very large to achieve 50% medium traffic load, which will significantly increase the simulation complexity and could become unaffordable for SLS. Additionally, it is very time consuming to search one appropriate total UE number for each target RU because one search has to take multiple blind-trials of total UE number. Therefore, it is unaffordable in term of simulation load to run such search for each cost reduction factor, e.g. 3 searches for iterating among 1Rx/2Rx/4Rx, and 6 searches for iterating among the combinations of 1Rx/2Rx/4Rx and 64QAM/256QAM. More importantly, it becomes almost impossible to compare the results of one company source between different settings of cost reduction factors, thus also impossible to have comparison across companies. For example, to compare the UPT between the factor 1Rx and 2Rx, different total simulated UE number have to be tuned to fulfil a target RU, which results in that the difference of UPTs are mainly contributed from the difference of simulated UE number.  **Option2**: The total simulated UE number is fixed for each evaluated cost reduction factor, e.g. 1Rx v.s. 2Rx, DL 64QAM v.s. 256QAM, , the performance metrics are RU ,UPT and cell average SE. [in reference to R1-2004270 by Orange]. To be specific, the first step of SLS is to determine the total simulated UE number which adapts to the target RU with 100% legacy UE as reference, and is applied to the other UE percentages and not changed for any cost reduction factors, as shown in the table below,    We consider that Option2 for network performance evaluation is a more reasonable way, and it is less complicated than the simulation of Option1. We propose the following,  ***Proposal****:*  *For REDCAP SLS, the total simulated UE number is fixed for each evaluated cost reduction factor, and is determined only by target RU with 100% legacy NR UE in the system bandwidth (i.e. 0% REDCAP UE) as reference.*   * Note: the system bandwidth is the same as the UE bandwdith of legacy NR UE. |