3GPP TSG-RAN WG1 Meeting #102-e Tdoc R1-200xxxx

e-Meeting, August 17th – 28th, 2020

**Agenda Item: 8.6**

**Title: FL summary #3 for RedCap evaluation templates**

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

**Document for: Discussion, Decision**

# 1 Introduction

This is FL summary #3 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
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Initial proposals and responses are documented in FL summary #1 (FLS1) in [R1-2007476](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2007476.zip) and FL summary #2 (FLS2) in R1-2007477 ([Docs](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2007477.zip), [Inbox](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Inbox/R1-2007477.zip)).

# 2 Template for cost reduction evaluation

An updated draft template is provided in [RedCapCostTemplate-v002.xlsx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Inbox/drafts/8.6/PostPhase1/RedCapCostTemplate/RedCapCostTemplate-v002.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 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 (white cells in 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”.

Several responses in the second round of the email discussion (see FLS2) discussed whether “*Reduced number of DL MIMO layers*” and “*Reduced number of Rx antennas*” should be considered as individual cost reduction techniques or not. The FL recommendation in FLS2 was to consider them separately, and the main reason for this recommendation is that otherwise the FR1 TDD tab will become a bit messy. For FR1 TDD, both the number of DL MIMO layers and the number of Rx antennas can be reduced from 4 to 1 or 2, meaning that there are multiple combinations of numbers of DL MIMO layers and numbers of Rx antennas that would need to be captured in order to reflect all relevant cases, but it has already been agreed (see FLS2) to not evaluate combinations, only individual techniques. This is the main reason why the FL recommendation is to consider “*Reduced number of DL MIMO layers*” and “*Reduced number of Rx antennas*” as individual cost reduction techniques, even though other reasons have also been discussed in some of the responses. It should be relatively straightforward to evaluate them separately. Whether the total cost reduction from combinations of reduced numbers of DL MIMO layers and antennas can be estimated by adding the individual estimates or not can be discussed in the next step when cost reduction from combinations of techniques is addressed.

Two responses (see FLS2) proposed to keep HD-FDD operation type B in the template. In line with this, HD-FDD operation type B has been reinserted in the latest version but with the note “*lower priority than Type A*”.

One response (see FLS2) proposed to not include the Yes/No question regarding RF savings accumulation across supported bands. Given that other responses did not express concerns with the Yes/No question which was requested in one response in the first round (see FLS1), it is kept in the latest version.

One response (see FLS2) proposed to change the name of the template to reflect that it only captures cost reduction estimates, not other impacts from the complexity reduction techniques. The FL understanding is that this is already quite clear, so no name change has been done at this point.

**Question 2-1b: 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? Please do not repeat earlier discussions.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung  | OK |
| CATT | We are generally OK with the template. Regarding to HD-FDD operation type B, we would like to confirm whether “*lower priority than Type A*” means “*Optional*” for companies to report. Regarding to the interrelation of “*Reduced number of DL MIMO layers*” and “*Reduced number of Rx antennas*”, maybe we can consider that:* For “*Reduced number of Rx antennas*” case, both the number of Rx antenna and the number of DL MIMO layers are reduced to the same value (as natural), i.e. 2 or 1;
* For “*Reduced number of DL MIMO layers*” case, only the number of DL MIMO layer is reduced to 2 or 1, but the number of Rx antenna remains unchanged, i.e. remains 2 for FR1 FDD and FR2 TDD, and remains 4 for FR1 TDD.
 |
| vivo | OK |
| OPPO | OK |
| Ericsson | OK |
| Qualcomm | OK |
| FL (Ericsson) | Regarding CATT’s comment about HD-FDD operation type B: The RAN1#101-e agreement is to “*Study HD-FDD operation Type A and Type B (as defined in LTE) in RAN1, where study of Type A is prioritized*”. The agreement does not state that study of Type B is optional, but given the time constraints, it seems likely to the FL that some companies may choose to provide results for Type A but not for Type B. So, in practice the evaluation of Type B will probably be regarded as optional by some companies. If lack of results for Type B turns out to be problematic somehow, perhaps companies can be asked to provide additional results at a later stage.Regarding CATT’s comment about the interrelation of “*Reduced number of DL MIMO layers*” and “*Reduced number of Rx antennas*”, one issue with the approach proposed by CATT is that it would require evaluation of FR1 TDD combinations such as 1 layer with 4 Rx and 2 layers with 4 Rx but not e.g. 1 layer with 2 Rx. In order to avoid including many combinations already during this stage when the focus is supposed to be on individual techniques, it seems to the FL that it would be good to evaluate the reduced numbers of layers and the reduced numbers of antennas separately, and then the evaluation of the combinations will hopefully be relatively straightforward to evaluate. |
|  |  |

# 3 Template for power saving evaluation

An updated draft template is provided in [RedCapPowerTemplate-v001.xlsx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Inbox/drafts/8.6/PostPhase1/RedCapPowerTemplate/RedCapPowerTemplate-v001.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?**

On Q3-1, all responses except one (i.e. 12 out of 13 companies) explicitly support to use the power saving Tab-3/4/5/6 to collect the evaluation results with some further modifications:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Index**  | **Tab(s)** | **Proposal**  | **Proposed by**  | **Other company inputs** |
| 1 | Tab-1 | Clarify TDD UL/DL configuration for power evaluation. Proposed to use the configuration agreed for capacity improvement.  | Vivo | No: OPPO (leave companies to report) |
| 2 | Tab-1 | Align the DCI format size with 40 bits | Intel |  |
| 3 | Tab-1 | Add a note to a baseline traffic model tab that companies to report the assumption of DRX being used or not.  | Intel |  |
| 4 | Tab-2 | Adding PUCCH/PUSCH power consumption | Ericsson | OPPO/ZTE (Partially yes, no need to add PUSCH) |
| 5 | Tab-2 | Modifying the ‘PDCCH+PDSCH’ power consumption model as follows: P(X) = (1-*a*)PPDCCH+PDSCH+*a*\*PPDCCH+PDSCH\*X | ZTE |  |
| 6 | Tab-2 | Align the ordering of ALs of PDCCH for a given number of blind decoding  | ZTE |  |
| 7 | Tab-2 | Add the following to the power consumption model table: ‘companies to report the power consumption modelling for 3-symbols CORESET Configuration and reduced number of non-overlapped CCEs’ | Intel |  |
| 8 | Tab-2 | Add a note to clarify 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 Tab-7 and the power saving results in Tab-3/4/5/6. | Huawei |  |
| 9 | Tab-2 | Add a note to clarify how the BD is reduced in the comment column when providing power saving gain results in Tab-3/4/5/6 | Huawei |  |
| 10 | Tab-3/4/5/6 | Add additional tab to capture time percentage values for different power states for different traffic model.  | Ericsson | OPPO (Intermediate values) |
| 11 | Tab-3/4/5/6 | Add absolute numbers for power consumption in power unit for each case in Tab-3/4/5/6 | Huawei |  |
| 12 | Tab-4/6 | Remove 50MHz BW for FR2 in Tab-4/6 | Samsung | Yes: Spreadtrum |

**Question 3-1a: Which of the listed proposals (P1, P2, …, P12) can be captured into the current template for power saving evaluation? If proposal(s) can be added with proper modification, please also provide details.**

Reponses from companies were summarized in the Table below:



It should be noted that it is always possible for companies to simulate other configurations and included the results in company contribution to discuss in RAN1 103 e-meeting.

Based on the responses, the power saving template was updated to v001 to reflect P2, P9 and P12 based on majority views:

* P2: Align the DCI format size with 40 bits (without including CRC).
* P9: Add a note in template that companies to clarify how the BD is reduced in the ‘comment’ column in template when providing power saving gain results in Tab-3/4/5/6
* P12: Remove 50MHz BW for FR2 in Tab-5/6

One company proposed to revise the power scaling equation: P(α) = max (Micro-sleep, α ∙ Pt + (1 – α) ∙ 0.7Pt)) with removing the cross-slot scheduling case. However, it should be noted that even in case of cross-scheduling, the power consumption is reduced in accordance to the reduced BDs, which this equation intends to capture. In any case, it is out of scope of this email thread and difficult to converge in email discussion. We can further discuss in RAN1 103 e-meeting if companies still have concerns.

**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?**

On Q3-2, all responses except one (13 out of 14 companies) support to use the Tab-7 for PDCCH blocking rate evaluation result collection. One company is ok with Tab-7 except some clarifications on the example numbers in bracket, e.g. number of users and the assumption of CORESET bandwidth.

Some modifications on Tab-7 were briefly summarized in table below for further discussions:

|  |  |  |  |
| --- | --- | --- | --- |
| **Index**  | **Tab(s)** | **Proposal**  | **Proposed by**  |
| 1 | Tab-7 | Adding note to clarify the “Number of users (e.g., 10)”  | Vivo: Clarify that it is the number of simultaneously scheduled UEs in a slot and company reports how the value is obtained, e.g. deployment scenario, traffic model, resource utilizationOPPO: Clarify either “number of simultaneously scheduled UEs in a slot” or “the system schedules the band with x user and the scheduling of user is based on the traffic models”Samsung/Futurewei: A range of values e.g. 1-10 and left it for company report. ZTE: Not use SLS here. |
| 2 | Tab-7 | Create separate Tab for 1Rx and 2 Rx case due to different AL distributions.  | Huawei |
| 3 | Tab-7 | Correct the candidate number of AL16 in the column ‘E’ of first table from ‘2’ to ‘1’ | Huawei |

It should be noted that P2 was discussed later in Q3-3a, due to the dependency on the outcome of the following Q3-3 discussions, e.g. which aggregation level distributions can be agreed for evaluation. If nothing was agreed for aggregation level distribution (i.e. Q3-3), separate 1 Rx/2 Rx Tabs maybe not necessary since companies can provide results with reporting the number of Rx and the corresponding aggregation level distributions even with a single Tab.

**Proposal 3-2: For PDCCH blocking rate evaluation, use Tab-7 in template to collect evaluation results with following modification(s):**

* **Revise “Number of users (e.g. 10)” to be “Number of users (e.g. 1 to 10)”**
* **Add a note in Tab-7 to clarify that “Number of users” represents the number of UEs that need to be scheduled simultaneously in a slot and company can provide different PDCCH blocking rates corresponding to a range of ‘number of users’ on different rows in Tab-7**

All responses seem support the proposals with different preferred values. 3 companies see the need to justify the use case of 10 UEs in a single CORESET. On the other hand, this configuration (i.e. 10 UEs) was preferred by 5 companies. Furthermore, 4 companies explicitly proposed to select a set of UEs number within the range. However, the preferred numbers are still diverged.

The following was reflected in Tab-7 template to capture the consensus:

* Revise “Number of users (e.g. 10)” to be “Number of users (e.g. 1 to 10)”
* Add a note in Tab-7 to clarify that “Number of users” represents the number of UEs that need to be scheduled simultaneously in a slot and company can provide PDCCH blocking rates corresponding to a range of ‘number of users’ on different rows in Tab-7

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.**

On Q3-3, all responses agree to limit AL distribution to align results for making the conclusion in TP. Companies positions can be categorized as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| **Configuration index** | **Supporting companies** | **Number of supporting companies**  | **Concerns** |
| 1 | Ericsson, Qualcomm, CATT, Huawei | 4 |  |
| 2 | Ericsson, Futurewei, CATT, MediaTek | 4 |  |
| 3  | Ericsson, Qualcomm, MediaTek  | 3 | Intel (Not realistic and only happen in case of poor network planning) |
| 4 | Ericsson | 1 | Futurewei (artificial), Qualcomm, Intel |
| 5 (Revised Config.1) | Vivo: [0.7, 0.2, 0.05, 0.03, 0.02] | 1 |  |
| 6 (Revised Config.1) | OPPO: [0.4, 0.5, 0.05, 0.03, 0.02] | 1 |  |
| 7 (Revised Config.1) | Huawei: [0.3, 0.5, ~~0.05~~, 0.10, ~~0.03,~~ 0.06, ~~0.02,~~ 0.04] (for 1Rx case) | 1 |  |
| 8 (Revised Config.1) | Intel: [0.5, 0.4, 0.07, 0.02, 0.01]. | 1 |  |

Most responses prefer to categorize different cases into cases e.g. good/medium/poor coverage, which represents different UEs SINR distribution in network. Configure 2 are preferred by all of responses and seems agreeable as one of configurations. Companies views on Configuration 1 are still diverse with several modifications (i.e. Configuration 5/6/8) brought up to the table.

In addition, one company proposed to clarify Configurations 1-4 above is assumed with 2 Rx. Correspondingly, it was also proposed to consider configuration 7 above for PDCCH blocking rate evaluation.

**Question 3-3a: Can we clarify that Configurations 1-4 are applied for 2 Rx case? If yes, can we agree to use Configuration 7 above for 1 Rx case for power saving evaluation as proposed by Huawei? Please provide some justification for each input.**

Reponses from companies on Q3-3a can be summarized as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| **Proposals**  | **Yes** | **No** | **Num. of companies**  |
| Configuration 1-4 for 2 Rx | Futurewei, Vivo, Huawei, Qualcomm, Samsung | Ericsson, CATT, MediaTek, ZTE, Nokia, Intel, LG,  | Yes: 5No:7 |
| Configuration 7 for 1 Rx | Futurewei, Huawei,  | Ericsson, Vivo, CATT, MediaTek, Qualcomm, ZTE, Nokia, Intel, LG, Samsung, OPPO | Yes: 2No: 11 |

Note that, the configuration is counted on a per cell basis, instead of per UE AL distribution. In addition, it is great if we can adopt at least configuration that all interested companies can simulate it. Other configuration can be left company to select and report.

**Proposal 3-3: PDCCH aggregation level distribution configuration 1 and 2 listed above are used to evaluate power saving benefit of PDCCH monitoring. Other configurations are optional.**

Responses from companies on P3-3 can be summarized as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| **Proposal**  | **Yes** | **No**  | **Num. of companies**  |
| P3-3 | Futurewei, Ericsson, CATT, Huawei, ZTE, Nokia, Samsung, OPPO | Vivo (Config-1), MTK/LG (Config-2/3), Qualcomm (at least keep Config-3), Intel (Config-1),  | Yes: 8No: 5 |

It seems that 12 out of 13 responses are ok with at least Configuration 1 (and perhaps have Configurations 2 and 3 as optional and leave companies to report).

**Question 3-3b: Can the updated spreadsheet v001 be used to collect the power saving evaluation results for Redcap UEs? If not, what other aspects need to be added? Please do not repeat earlier discussions.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung  | Yes |
| CATT | Yes, we are fine with the template. |
| vivo | Yes but it seems the proposed note (as following) is missing.*Add a note in Tab-7 to clarify that “Number of users” represents the number of UEs that need to be scheduled simultaneously in a slot and company can provide PDCCH blocking rates corresponding to a range of ‘number of users’ on different rows in Tab-7*  |
| OPPO | Yes.We also agree the number of UEs can mean simultaneous transitions in same occasion. But, the range will be up to companies. Could be only for few pair of value{(2, 20%), (4, 33%) …}  |
| Huawei, HiSilicon | We are generally fine but still have the following aspects need to be resolved:1. We didn’t find the note below in the template, which seems common understanding and also proposed by feature lead in the FL summary.
* *Add a note in Tab-7 to clarify that “Number of users” represents the number of UEs that need to be scheduled simultaneously in a slot and company can provide PDCCH blocking rates corresponding to a range of ‘number of users’ on different rows in Tab-7*
1. According to the second round discussion, we found that in response to P8 of Question 3-1a some companies claimed that only BD reduction values can be common for the results in Tab3/4/5/6 and Tab7. However, we think the PDCCH blocking, which is the outcome of Tab7, shall impact the scheduling of gNB and therefore impact the slot type distribution of UEs. The slot type distribution shall impact the power consumption evaluations. This impact should be reflected, otherwise the power consumption evaluations does not reflect the BD reduction impact. Therefore, we propose to at least add a note: companies to clarify the block rate of PDCCH for each AL used in Tab3/4/5/7.
 |
| Ericsson | Generally Yes. We think it is not necessary to include DCI size as a baseline parameter in Tab-7, if we have consensus on using one of the configurations on the FL’s list.We are fine with not capturing PUCCH/PUSCH power consumption model in the template. But companies should be able to report them in the ‘comments’ column, if needed. |
| Qualcomm | Yes |

**Question 3-3c: Can Configuration 1 ([0.5, 0.4, 0.05, 0.03, 0.02]) to be used for PDCCH blocking evaluation and other configuration(s) are left for company report?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| Samsung | N | Configuration 1 seems to be too ideal. We think it’s better to prioritize Configuration 2 than configuration 1.  |
| CATT | Y | We would like to confirm that Configuration 1 is applied to both 2Rx and 1Rx in FR1.  |
| vivo | Y | We are fine to use configuration #1 as the common evaluation assumption, other configurations can be optionally used and reported by company.  |
| OPPO | N | We would have configuration 2. If we can not converge, please take the mean value between 1 and 2: 0.45, 0.45, … |
| Huawei, HiSilicon | Partially Yes | We are fine with the configuration 1. In the second round discussion, we tried to clarify whether the AL distributions should be based on RX number assumption. However, there is no technical response to our second response in the second round discussion, which is marked as ‘Huawei, HiSilicon\_2’.Even though the configuration 1 is assumed as a cell level distribution, the distribution would be different for 2Rx and 1Rx UEs deployed in the cell. During the discussion, some companies also agreed the configuration is based on two RX number assumption. So it would be better to add a note ‘companies to report the Rx assumption for their results for Tab7’. |
| Ericsson | Y | It is good to have at least one “mandatory” case for calibration purposes. Results for additional cases can of course also be reported. |
| Qualcomm | Y |  |

# 4 Template for coverage recovery evaluation

Updated draft templates are provided in:

* Rural 700 MHz: [RedCapCoverageTemplate-Rural700MHz-v002.xlsx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Inbox/drafts/8.6/PostPhase1/RedCapCoverageTemplate/RedCapCoverageTemplate-Rural700MHz-v002.xlsx)
* Urban 2.6 GHz: [RedCapCoverageTemplate-Urban2.6GHz-v002.xlsx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Inbox/drafts/8.6/PostPhase1/RedCapCoverageTemplate/RedCapCoverageTemplate-Urban2.6GHz-v002.xlsx)
* Urban 4 GHz: [RedCapCoverageTemplate-Urban4GHz-v002.xlsx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Inbox/drafts/8.6/PostPhase1/RedCapCoverageTemplate/RedCapCoverageTemplate-Urban4GHz-v002.xlsx)
* Indoor 28 GHz: [RedCapCoverageTemplate-Indoor28GHz-v002.xlsx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Inbox/drafts/8.6/PostPhase1/RedCapCoverageTemplate/RedCapCoverageTemplate-Indoor28GHz-v002.xlsx)

On each of the templates, 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 that will be captured to the TR. On the tabs for collecting results, the first column contains the reference UE case, followed by one or two columns for the RedCap case. Currently, only examples are provided for reference.

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

Based on the responses in the first round of the email discussion (see FLS1), the link budget template has been updated with change marks to align with the agreement in the CE SI including the agreement on UE antenna gain for FR2. Regarding antenna gain modeling, the antenna gain component 3 and component 4 are merged into one row, i.e. row (4) for transmitter and row (11) for receiver. The antenna gain component 2 is in anther separate row, i.e. row (5) for transmitter and row (11bis) for receiver. For the calculation of antenna gain component 3 and component 4, company is required to report the antenna gain correction factor, i.e. Δ2 for gNB and Δ3 for UE. In some cases, the antenna gain correction factor can be void, e.g. Δ3 fixed to zero for FR1, and thus no reporting is needed. It is noted that Δ1 is not included in the link budget template, and the gain of antenna gain component 2 is reported. The reason is that the gain of antenna gain component 2 can be zero in some cases. The report of the antenna gain component 2 instead of Δ1 makes the calculation simple.

Regarding rows (24), (25a), (25b) and (27), the notes have been updated with the CE SI agreement. As commented in one response, the row (27) penetration margin is dependent on the scenario “O-to-I” or “O-to-O”, and therefore the FL recommendation is to declare also the scenario when reporting the value. Currently for FR1, the values used in IMT-2020 (channel model A) for the O-to-I scenario is provided here as a reference, and for FR2, zero values are used due to no reference in the IMT-2020 self-evaluation.

For FR2, based on the CE SI agreement, single panel with total 8 antenna elements, i.e. (M, N, P) = (2,2,2) is used for LLS. However, there is no discussion on the number of antenna elements for RedCap UE. The FL recommendation is to reuse the same array structure for RedCap. In case of single Tx or Rx chain, only the antenna elements in one polarization is used, i.e. 4 instead of 8. Companies are invited to provide their views on this issue.

**Summary of the 2nd round discussion (see FS2):**

* 1. **Remove ”could vary across different physical channel” in the notes in row (5) and (11bis) - Huawei**

🡪 FL perspective: The notes have been updated to address this issue in the latest link budget template v002. Companies are encouraged to check the rows.

* 1. **Add a note to row (10bis) ”For FR1 DL, it is supposed to be equal to (10)” - Huawei**

🡪 FL perspective: Link budget template v002 has addressed this value. Companies are encouraged to check the rows

* 1. **Use the same PSD value for both Urban 4GHz and 2.6GHz - Huawei**

🡪 FL perspective: According to the CE SI agreement, only 33dBm/MHz is considered for 2.6GHz while either 24 or 33 dBm/MHz is supported for 4GHz. If the same PSD value of 33dBm/MHz is used for both 2.6GHz and 4GHz, then the MCL/MIL difference is expected to be small. The usage of 24dBm/MHz for 4GHz allows to identify possible different bottleneck channels and provide full analysis for all the concered scenarios. However, in order to address the concern from the company, the LB template is updated to allow the company to report the PSD value for 4GHz.

* 1. **The noise figure values for FR2 in row (13) changed to 10dB for UE and 7dB for gNB according to ITU-R M.2412-0 - Huawei**

🡪 FL perspective: There is no agreement on the noise figures in RAN1. The IMT-2020 evaluation uses 7dB for UE and 5dB for gNB for FR1 link budget analysis. The FL recommendation is to align the assumption used in the CE SI to avoid divergence and repetition of discussions. The note in row (13) has been updated to address this issue.

* 1. **The values of row (5) and (11bis) for FR2 can be reported by the companies - vivo**

🡪 FL perspective: Link budget template v002 has addressed this value. Companies are encouraged to check the rows

* 1. **Make the 4GHz Urban as the optoinal scenario - ZTE**

🡪 FL perspective: There is a note in the LB template to clarify that 4GHz is the second choice for FR1 TDD.

* 1. **Clarify how simulation results for Urban 700MHz are provided/collected and whether the same table can be reused - Huawei**

🡪 FL perspective: The FDD bands in Urban has been discussed in ” [102-e-NR-RedCap-03] Coverage recovery and capacity impact for NR RedCap” with no agreement. The FL recommendation is to firstly collect the coverage evaluation results firstly for the 4 concerned scenarios and bands, and companies are free to provide results for other scenarios and bands in their contributions to RAN1#103-e.

* 1. **The in-car peneration loss is modeled in the same way as Table A.2.2-1 of TR 38.802 - Qualcomm**

🡪 FL perspective: In the LB template, the value of the peneration loss can be reported by company. From FL point of view, there is no issue to do so.

* 1. **Align the LB template structure with the CE SI - Intel**

🡪 FL perspective: The discussion in the CE SI is still on-going and the LB template is not stable. Therefore, the FL recommendation is to use the proposed LB template as the staring point and make some further update only when there are significant changes that affect the LB calculation.

* 1. **UE antenna configuration for RedCap UEs for FR2**

🡪 FL perspective: Since no company showed their concern for the FL proposal on UE antenna configuration for RedCap UE for FR2 (i.e. assuming same array configuration for RedCap. In case of one Tx/Rx chain for UE, only the elements in one polarization are used.). Therefore, this proposal can be treated as offline consensus. The bracket in the notes of row (1) and row (10) are removed.

**Question 4-1b: Can the spreadsheets be used to collect coverage recovery evaluation results? If not, what other aspects need to be added? Please do not repeat earlier discussions.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | OK |
| CATT | OK |
| vivo | OK in general. One minor comment is about FR2 template, there are notes for row 4a and 11a “For RedCap, can adjust for UE antenna efficiency loss for FR1.”, which should be deleted.  |
| OPPO | OK |
| Huawei, HiSilicon | Regarding the issue (1-3), thank you for taking it into consideration, we suggest to add a note under (3a) for 4GHz TDD that the value is either 33 or 24 dBm/MHz because it is not fully up to company report. |
| Ericsson | OK |
| Qualcomm | Yes, the spreadsheets can be used to collect evaluation results for coverage recovery. |

The CE SI has just agreed to assume an uplink total radiated power of 12 dBm for link budget calculation in FR2. The earlier assumption 23 dBm total transmission power implies 34 dBm EIRP which was considered too high for a power class 3 (handheld) UE. The FL would invite companies to provide their views on using the new UL Tx power assumption for link budget calculation in FR2.

**Conclusion (by the CE SI)**

* For link budget calculation in FR2, an uplink total radiated power of 12dBm is also considered, for baseline performance evaluations of commercial power class 3 UEs.
* Note: with the assumption of total maximum of 11 dBi antenna gain.

**Question 4-1c: For link budget calculation in FR2, can we use the new uplink Tx power assumption agreed in the CE SI, i.e. the values of row (3b) and (3bis) for uplink changed from 23 to 12 dBm?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | We don’t want to change from 23dBm to 12dBm for coverage evaluation, but we can be ok to additionally consider the analysis for 12dBm for power class 3 UEs if majority companies support it.  |
| CATT | We are fine with the change. We agree that it is not realistic to assume the UE UL EIRP to be as high as 33dBm (with TRP=23dBm) in FR2. By changing the TRP from 23dBm to 12, the EIRP will be reduced to a more reasonable value, i.e. 22dBm. |
| vivo | OK |
| OPPO | Yes, this can be aligned. |
| Huawei, HiSilicon | OK |
| Ericsson | OK.Regarding UE TRP, our view is that 23 dBm TRP is a bit too high for commercially viable UEs in FR2. |
| Qualcomm | Yes.  |

# 5 Template for capacity impact evaluation

An updated draft template is provided in [RedCapCapacityTemplate-v002.xlsx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Inbox/drafts/8.6/PostPhase1/RedCapCapacityTemplate/RedCapCapacityTemplate-v002.xlsx). The first tab is general note for the template, followed by several tabs for collecting the results for different scenarios and frequency bands. The DL and UL results are separated in different tabs. On each tab, the non-full buffer traffic and the optional full buffer traffic are included for different percentages of RedCap UEs and different UE complexity reduction features (i.e. 1 Rx or 2 Rx).

For the non-full buffer traffic, the performance metric is based on 5% and 50% UPT, and company can report the actual value of resource utilization (RU) for low and medium loading. An SE row is also included in the non-full-buffer traffic table. For the buffer traffic, the performance metric is based on the cell average SE.

In the first-round email discussion, several responses (see FLS1) commented to clarify the purpose of the SLS evaluation. According to the SID, the evaluation of impact to network capacity and spectral efficiency is required under both UE complexity reduction and coverage recovery. However, there are no agreements on what coverage recovery solutions can be considered for RedCap UEs. The FL recommendation is to collect the evaluation results at least for UE complexity reduction, and companies are free to provide results for coverage recovery in their contributions to RAN1#103-e. Then we can discuss and decide whether to include the results or not in the TR in RAN1#103-e.

A couple of responses comment on the UE complexity reduction features for evaluation. One response proposes to start from the most ambitious cost reduction combination, e.g. 20 MHz, 1 layer, 1 Rx, DL 64QAM, and UL 16QAM in FR1 FDD. The FL recommendation is that both 1Rx and 2Rx are evaluated, and for other UE complexity reduction features, probably we can consider to limit the choice for easily comparing the results, e.g. 20MHz, 1 layer, DL 64QAM and UL 16QAM in FR1 and 100MHz, 1 layer, DL 16QAM and UL 16QAM in FR2.

Several responses propose to collect the statistics (e.g. UPT, cell SE) separately for RedCap and eMBB UEs. Based on the responses, the collection of the results separately for the RedCap and eMBB UEs as well as overall statistics has been included in the updated template.

One response comment whether the loading level is determined based on the limiting link (either DL or UL). To simplify the evaluation, the FL recommendation is to determine the loading separately for DL and UL for achieving a given RU target. In other words, the joint consideration of DL and UL loading is not required. One response also comment it is difficult to perfectly match the exact loading ratio, e.g. 30% or 50%. The FL recommendation is to use the 30% and 50% loading target as much as possible, and company can also declare the other values.

One response proposes to make FTP model 3 mandatory for both RedCap and eMBB UEs, and IM traffic model can be optional. Generally, the IM traffic model is used for less frequently small packet transmission while FTP model is used for file transfer, storage and application download and update. Therefore, the IM traffic model is more aligned with the RedCap user cases. It is also noted that in the last meeting, the IM traffic model has been agreed as the baseline for power saving evaluation of RedCap UE. Therefore, the FL recommendation is to follow the last meeting agreement on the non-full buffer traffic model, e.g. both FTP model 3 and IM traffic model are considered up to company to report.

One response proposes to discuss and decide whether the total number of UEs including both eMBB and RedCap UEs can be fixed for each evaluated cost reduction feature. For example, the total number of UEs is firstly determined assuming 0% RedCap UE ratio when adapting the target RU, and then applied to the other RedCap UE ratios and not changed for other cost reduction features. Although the proposal can reduce the efforts to determine the number of UEs, the target loading cannot be achieved when the RedCap UEs are added to the cell and the impact to the eMBB UE may not be correctly evaluated. Therefore, the FL recommendation is that for evaluation of each percentage of RedCap UE and eMBB UE, company are encouraged to determine the loading level to achieve the target RU.

**Summary of the 2nd round discussion (see FS2):**

* 1. **UE compelxity reduction features for capacity evaluation**

🡪 FL perspective: Seems most repsponses support the FL recommendation on the UE complexity reduction features. Also as commented by Ericsson, additional combinations can be evaluated and reported in contributions to RAN1#103-e.

* 1. **Clarify the SE defintion for non-full buffer traffic – Huawei, Qualcomm, LG**

🡪 FL perspective: Agree with the Huawei’s proposal on the SE for the non-full buffer traffic, i.e. SE (bps/Hz)= cell average throughput(Mbps) / ( cell bandwidth(MHz) \* RU). The capacity template v002 has address this issue.

* 1. **Clarify the reference eMBB UE configuation for evaluation – ZTE**

🡪 FL perspective: The FL recommendation is to use the same reference UE configuration as agreed in RAN1#101-e, i.e. 4Rx/1Tx for FR1 TDD and 2Rx/1Tx for FR2 for the SLS evaluation.

* 1. **Make FTP traffic model 3 mandatory for both RedCap and eMBB UEs – Huawei**

🡪 FL perspective: The IM model has been agreed for RedCap UE power saving evaluation, it may not be suitable to make it optional for capacity evaluaiton. In the current template, the traffic model used for RedCap UEs is up to company to report From FL point of view, there is no issue to do so.

* 1. **Use the same number of UEs for different RedCap UE ratios for the non-full buffer traffic– Huawei**

🡪 FL perspective: The same comment has been raised in the 1st round of discussion. From FL point of view, the issue with this proposal is the actual RU for the high pencetage of RedCap UEs can be very low if the total number of UEs is based on 0% RedCap UE ratio, which may not be aligned with the agreement on the target RU. Also, using the same loading irrespective of the ratio of RedCap UEs allows to evaluate the impact of UE complexity reduction to the legacy eMBB UEs. To address the concern from company, probably we can include that other SLS evaluation methodologies are not precluded, and companies are free to provide evaluation results in their contributions to RAN1#103-e.

**Question 5-1b: Can the spreadsheet be used to collect the capacity impact evaluation results for UE complexity reduction? If not, what other aspects need to be added? Please do not repeat earlier discussions.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| vivo | We think a aligned assumption for simulated bandwidth for reference UE and redcap UE should be given, we propose the following* For FR1 (both 2.6GHz and 4GHz), the simulated bandwidth for reference UE is 100MHz and for redcap UE is 20MHz
* For FR2, the simulated bandwidth for reference UE is 100MHz and for redcap UE is 100MHz or 50MHz.

Another minor comment is that we think for SE it is better to use “bit/s/Hz”, instead of “bits/RE”. |
| Huawei, HiSilicon | NoRegarding the sheet of General note, please update “1 layer” to “1 or 2 DL layers” because 2 DL layers should be an option for the case of 2Rx.Regarding issue (1-4), as commented twice before, the point is that effective 1:50 traffic ratio of REDCAP UEs over reference UEs are far too small which can downplay the impact of cost reduction on the real network operation. Additionally, what to be evaluated in capacity SLS is clearly not power saving, thus we are afraid that we fail to follow the logic to reuse power saving model, IM model to network capacity evaluation. To make progress, we suggest to add a note to the usage of IM model for REDCAP UE in capacity SLS that the effective traffic ratio of REDCAP UEs over reference UEs should be either 25% or 50%. Those two ratio values are referred to the agreed percentage of UE numbers.Regarding issue (1-5), we feel the reason resulting in FL’s worry is actually the 1:50 too low traffic ratio of REDCAP UEs as pointed out in the issue (1-4). The resulting RU variance can be reduced by our proposed traffic ratio limitation. More importantly, the SLS methodology seems unclear in the proposal and excel file. The key issue is to evaluate the impact from introduction of REDCAP UEs rather than the increase of total number of UEs. Therefore, we suggest to align the SLS evaluation methodology to distinguish the impact of cost reduction feature from the impact of varying number of UEs. Otherwise, it is almost impossible to conclude the impact of cost reduction feature by aggregation of companies’ SLS results in the coming meeting. Maybe FL and any company could clarify how it works and how to conclude the impact of cost reduction feature. In our understanding, the methodology we suggested is more reasonable and efficiency. i.e. “The total number of UEs is firstly determined assuming 0% RedCap UE ratio when adapting the target RU, and then applied to the other RedCap UE ratios and not changed for other cost reduction features. Then the changes of RU can reflect the performance loss due to RedCap UE complexity reduction. Meanwhile, the other metrics also be used to evaluate the performance loss, such as, SE and UPT.” |
| Ericsson | Yes.Regarding vivo’s comments on bandwidths, our view is:* The total system bandwidth in SLS can be 100 MHz for both FR1 and FR2. This is aligned with the LLS assumptions.
* In FR1, the scheduled bandwidths for reference and RedCap UEs can be up to 100 MHz and 20 MHz, respectively.
* In FR2, the scheduled bandwidths for reference UEs can be up to 100 MHz (aligned with the LLS assumption), and up to 100 MHz or 50 MHz for RedCap UEs.
 |
| Qualcomm | Yes.Regarding UE complexity reduction, we think reduced BW and modulation restriction of RedCap UE can be accounted for in the SLS. For the study of BW reduction, we agree with the views of Vivo and Ericsson. For the study of modulation restriction, we can stick with the RAN1#102 agreements for FR1 and FR2, respectively. |