**3GPP TSG RAN WG1 #102-e R1-20XXXXX**

**e-Meeting, August 17th - 28th, 2020**

**Agenda item:** 8.6.3

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

**Title:** FL summary on Coverage Recovery and Capacity Impact for NR RedCap (Appendix: Initial proposals for high priority)

**Document for:** Discussion/decision

# Introduction

This document captures the 2nd step of the RAN1#102-e email discussion [102-e-NR-RedCap-03] under the AI 8.6.3 (Study on Support of Reduced Capability NR Devices: coverage recovery and capacity impact).

This document deals with the initial proposals for high priority questions (Q1, Q2, Q4, Q5 and Q6) and one medium priority question (Q10), which was identified to have impact on other discussion.

* High priority aiming at the discussion/approval on 8/20
	+ May be controversial or have impact on other discussion
* Medium priority aiming at the discussion/approval on 8/26
	+ Important for simulation but have isolated impact to other topics.
* Low priority for last check on 8/28
	+ Less controversial.

# Evaluation methodology

## Question 1

**Question 1: Should the target of coverage recovery be aimed to compensate the coverage loss for the bottleneck channels(s) of the RedCap UE to achieve the same target performance as the reference NR UE?**

Regarding Question 1, there does not seem to be consensus on the target of coverage recovery for RedCap.

Some responses indicate that bottleneck channels are the most important, other channels should also be considered for coverage recovery.

Several responses indicated that the bottleneck channels may be different in different deployment scenarios and the target coverage of the reference UE may also be different in different scenarios.

One response requests a clarification that coverage recovery is to improve the performance loss due to the complexity reduction schemes rather than the imbalance between different channels.

The companies’ preferences are summarized below.

Alt 1: Bottleneck channels (1~~8~~9)

* vivo, Futurewei, Sony (most important), ZTE, Sanechips, Ericsson, Panasonic, OPPO (first priority), DOCOMO, Sharp(prioritized), Sequans(prioritized), LG, Apple, Intel, Huawei, HiSilicon, Nokia, NSB, CATT

Alt 2: All the channels (10)

* Xiaomi, Sony (other channels considered also), Convida, InterDigital, OPPO (second priority for other channels), Lenovo, Motorola Mobility, Qualcomm, CMCC, Spreadtrum

ZTE: How to find the bottleneck channels

Vivo and Samsung: discuss and decide the cell edge target data rate for PDSCH/PUSCH

FutureWei: no need to exactly match with a reference NR UE but based on a reference deployment

Ericsson: tradeoff between a small coverage loss versus UE complexity/cost reduction

Since it is not clear what is the impact of complexity reduction on the coverage due to no agreement on the target data rates for the RedCap study, there is no common understanding on what the bottleneck channels are. It is suggested to come back to this topic at the next meeting. A possible way forward is to agree on the high-level target to compensate the coverage loss resulting from complex reduction techniques.

**Proposal 1: The coverage recovery for RedCap should be targeted to compensate the coverage loss due to UE complexity reduction if any.**

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| **Company** | **Comments** |
| DOCOMO | Fine with the proposal, while the proposal is almost the same as what is stated in SID, i.e., “Coverage recovery to compensate for potential coverage reduction due to the device complexity reduction.” |
| Ericsson | This formulation is a bit unclear. We do not think we need this proposal if proposal 2 is agreed.Minor comment: Ericsson was mis-spelled in the summary above. |
| vivo | Come back to this issue is fine but in that case we do not need proposal 1 as it seems just a repeat of what is currently written in the SID.Study functionality that will enable the performance degradation of such complexity reduction to be mitigated or limited, including [RAN1]:* Coverage recovery to compensate for potential coverage reduction due to the device complexity reduction.
	+ Note: For FR1, coverage analysis for wearables can include consideration of potential reduced antenna efficiency due to device size limitations as part of the antenna gains. The extent of additional recovery of coverage loss due to reduced antenna efficiency is to be limited to 3 dB
* The study includes evaluations of the impact to network capacity and spectral efficiency
 |
| CATT | Fine to come back to the issue later and agree that in this case proposal 1 is not needed. |
| ZTE,Sanechips | The target of coverage recovery is clear in the WID “Coverage recovery to compensate for potential coverage reduction due to the device complexity reduction”Therefore proposal 1 is already the confirmed by the WID. No need for further agreement in the WG level. |
| CMCC | As the comments in the above companies, this proposal is not needed. |
| Intel | Agree with vivo and E// that proposal 1 seems just repeating the SID objective and may not be needed.  |
| Samsung | Fine to come back this issue. Proposal 1 is not necessary. |
| Sharp | Fine with the proposal though it may not be required to be agreed. |
| Huawei, HiSilicon | We suggest to consider the proposal 1 and proposal 2 at the same time. Therefore, we suggest adding the limitation of “for the channels which performance are lower than the target performance”. |
| Panasonic | We agree with above companies that this proposal seems not necessary as it repeats the SID objectives |
| MediaTek | Agree with Ericsson, the proposal is not clear and maybe not needed give the other proposals below. |

## Question 2

**Question 2: Should the target performance for coverage recovery be based on the link budget of the bottleneck channel for the reference NR UE?**

Regarding Question 2, there seems no consensus although more responses indicate to support the target performance for RedCap UE should be based on the bottleneck channel(s) for the reference NR UEs.

**Yes:**

* Ericsson, Panasonic, OPPO, DOCOMO, Sharp, Qualcomm, CMCC, LG, Apple, Nokia, NSB, CATT

**No:**

* Xiaomi, Spreadtrum

Some clarifications and proposals are summarized below.

* Clarify whether the reference NR UE is Rel-16 UE without CE or Rel-17 UE with CE
* Clarify the target performance is based on link budget evaluation and the used target performance metric
* Clarify whether the Redcap UE could reuse the solutions identified in coverage enhancement to improve the same bottleneck channel of Redcap
* Coverage recovery for other channels such as CORESET0 may need also to be considered
* The target performance for Redcap UEs should reflect a typical network deployment, including the coexistence deployment.

Based on the proposals listed above, the following proposals can be considered.

**Proposal 2: For the channel(s) affected by complexity reduction, the following methodology can be used to determine the target performance for coverage recovery**

* Step 1: Obtain the link budget performance of the channel based on link budget evaluation
* Step 2: Obtain the target performance requirement for RedCap UEs within a deployment scenario
	+ FFS on the target performance requirement
* Step 3: Find the coverage recovery value for the channel if the link budget performance is worse than the target performance requirement

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| **Company** | **Comments** |
| DOCOMO | Agree with the proposal |
| Ericsson | Fine with this proposal. |
| vivo | Fine with this proposal. |
| CATT | Fine with the proposal |
| ZTE,Sanechips | OK. |
| CMCC | Fine with the proposal |
| Intel | Fine with the proposal |
| Xiaomi | OK with the proposal |
| Samsung | OK |
| Sharp | Fine with the proposal. |
| Huawei, HiSilicon | Agree with the proposal |
| Panasonic | Agree with the proposal |
| MediaTek | Fine with this proposal. |

**Proposal 3: Down-selection on the following options for the target performance requirement for RedCap UEs in next meeting**

* Option 1: The target performance requirement is identified by a target MCL within a reasonable deployment
* Option 2: The target performance requirement is identified by the link budget of the same channel of the reference NR UE within the same deployment scenario
* Option 3: The target performance requirement is identified by the link budget of the bottleneck channel(s) for the reference NR UE within the same deployment scenario
* Note 1: The definition of the reference NR UE is based on the agreement in RAN1-101e.
* Note 2: The “bottleneck channel(s)” are the physical channel(s) that have the lowest MCL or MIL or MPL

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| **Company** | **Comments** |
| DOCOMO | Agree with the proposal, while we prefer to down-select one of the options in this meeting so that we can evaluate/discuss Step 3 in proposal 2 in the next meeting further. |
| Ericsson | We prefer Option 3. It would be good to (down-)select already in this meeting.In our interpretation, “bottleneck channel(s)” are the physical channel(s) that have the lowest MIL. |
| vivo | We prefer option 1.For option 3, we have some questions:1. It seems clear already in the CE SI that PUSCH is the bottleneck among all channels for reference/normal UE, in this case does option 3 mean we only need to make sure that all the channels for RedCap UEs is not worse than PUSCH for reference/normal UE?
2. And does the bottle neck channel for reference/normal UE, i.e. PUSCH refers to the Rel-16 PUSCH or the enhanced PUSCH in Rel-17?
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| CATT | We prefer to down-select between option 1 and option 3.  |
| ZTE,Sanechips | OK with the proposal. But it could be that for some channel one option is adopted but for the other channels different options can apply. |
| CMCC | Agree with the proposal, we also think we should down-select the option in this meeting.In addition, whether using MIL or MPL should be clarified in option 2 and option3. |
| Intel | Our preference is Option 3. If possible, we could try to converge on an option or reduce the candidate options |
| Xiaomi | OK with the proposal. Option 2 is our first preference. But we can compromise to Option 3.  |
| Samsung | OK. |
| Sharp | Agree with the proposal and further down-selection is preferable. |
| Huawei, HiSilicon | We prefer Option1. Coverage analysis for RedCap UE must consider a reasonable network deployment. The target performance discussed in proposal 2 should reflect that. “bottleneck channels” are the physical channel(s) which have the MCL lower than the target MCL. |
| Panasonic | Our preference is option 3. |
| MediaTek | Agree with the proposal, and we prefer down-selection in this meeting if possible.Our preference is Option 3 and Option 2. |
| Moderator | One additional note is added to clarify the “bottleneck channel(s)”. |

## Question 4

**Question 4: For link level coverage evaluation, should the RedCap study include PUCCH, PUSCH, PDCCH and PDSCH? If not, what modifications are needed?**

Regarding Question 4, most responses seem to agree that at least PDCCH and PDSCH shall be evaluated and the evaluation of PUCCH and PUSCH can also be considered if complexity reduction schemes impacted the uplink.

**Yes (20):**

* vivo, ZTE, Sanechips, Ericsson, Panasonic, Samsung, InterDigital, DOCOMO, Sharp, Lenovo, Motorola Mobility, Qualcomm, Sequans, CMCC, LG, Apple, Intel, China Telecom, Nokia, NSB

**No (~~7~~8):**

* Xiaomi (at least PDCCH//PDSCH), OPPO (at least PDCCH/PDSCH), FutureWei (at least DL channels), Sony (no UL channels), Spreadtrum (focus on DL), Huawei, HiSilicon (at least PUSCH, PDCCH, PDSCH), CATT (at least PUSCH, PDCCH, PDSCH)

**Proposal 4: Link budget evaluation for RedCap should include at least PDCCH/PDSCH and PUCCH/PUSCH if complexity reduction schemes impact the uplink.**

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| **Company** | **Comments** |
| DOCOMO | Agree with the proposal |
| Ericsson | There seems to be a quite large majority for “Yes”, and furthermore it seems from the above summary that some of the “No” companies are not necessarily against PUCCH/PUSCH, since they say “at least PDCCH/PDSCH” or similar. Therefore, we suggest removing “if complexity reduction schemes impact the uplink”. |
| vivo | We are fine with Ericsson’s modification.  |
| CATT | We would like to clarify that what kind of evaluation is expected for the channel if there is no impact due to complexity reduction scheme. Is the intention to considered antenna efficiency loss? |
| ZTE,Sanechips | Agree with the proposal. |
| CMCC | Agree with the proposal. |
| Intel | Agree wither Ericsson modification.  |
| Xiaomi | Agree with CATT’s view. Currently, according to the statement in many contributions, the coverage loss in UL mainly resulted by the antenna efficiency loss and reduced BW(e.g., frequency diversity gain loss) |
| Samsung | OK |
| Sharp | Fine with the proposal. |
| Huawei, HiSilicon | Agree with the proposal |
| Panasonic | Share same view with Ericsson |
| MediaTek | Agree with CATT’s comment.  |

## Question 5

**Question 5: For link level coverage evaluation, should the RedCap study include also the initial access related channels, i.e. PRACH, Msg3, SSB, SIB1, Msg2 and Msg4? If not, what modifications are needed?**

Regarding Question 5, most responses seem to support the evaluation of the initial access related channels for the RedCap study. One response proposes the need of the evaluation for initial access related channels should depend on whether UE complexity reduction is applied to initial access channels.

The responses are summarized as follows.

PRACH:

* vivo, InterDigital, OPPO, DOCOMO, Lenovo, Motorola Mobility, CMCC, Apple, Intel (not support), China Telecom, Nokia, NSB, Huawei, HiSilicon (low priority)

SSB:

* vivo, Xiaomi, Sony, Samsung (not support), InterDigital, OPPO, DOCOMO, Sharp ~~(not support)~~, Lenovo, Motorola Mobility, CMCC, Spreadtrum, Apple, Intel (no support), China Telecom, Nokia, NSB, Huawei, HiSilicon (low priority), CATT

SIB1:

* vivo, Xiaomi, Sony, Samsung (not supported), InterDigital, OPPO, DOCOMO, Lenovo, Motorola Mobility, Qualcomm, CMCC, Spreadtrum, Apple, Intel (not support), China Telecom, Nokia, NSB, Huawei, HiSilicon (low priority), CATT

Msg2:

* vivo, Xiaomi, FutureWei, Sony, ZTE, Sanechips, Ericsson, Samsung, InterDigital, OPPO, DOCOMO, Lenovo, Motorola Mobility, Qualcomm, CMCC, LG, Spreadtrum, Apple, Intel, China Telecom, Nokia, NSB, Huawei, HiSilicon (low priority), CATT

Msg3:

* vivo, FutureWei, ZTE, Sanechips, InterDigital, OPPO, DOCOMO, Lenovo, Motorola Mobility, Qualcomm, CMCC, Apple, Intel, China Telecom, Nokia, NSB, Huawei, HiSilicon (low priority)

Msg4:

* vivo, Xiaomi, FutureWei, Sony, ZTE, Sanechips, Ericsson, Samsung, InterDigital, OPPO, DOCOMO, Lenovo, Motorola Mobility, Qualcomm, CMCC, LG, Spreadtrum, Apple, Intel, China Telecom, Nokia, NSB, Huawei, HiSilicon (low priority), CATT

PDCCH for Msg2/Msg3/Msg4:

* ZTE, Sanechips, Qualcomm, LG

**Proposal 5: Link budget evaluation for RedCap should also include Msg2/3/4 and PDCCH scheduling Msg2/3/4.**

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| **Company** | **Comments** |
| DOCOMO | Agree with the proposal in principle. To clarify the intention of the proposal, it would be better to add a note that “other initial access related channels are not precluded” as most companies support these channels. |
| Ericsson | PBCH & Type-0-PDCCH should be evaluated for 50 MHz UE BW in FR2. Also, note that Msg3 is not scheduled by PDCCH, but by RAR (PDSCH). |
| vivo | Fine with the proposal |
| CATT | Fine with the proposal |
| ZTE,Sanechips | Agree with the proposal. From initial analysis it seems Msg2/3/4 and the channel/signal scheduling these messages should be prioritized for coverage recovery.  |
| CMCC | Agree with DOCOMO, there are only few companies not support to evaluate PRACH/SSB/SIB1, we think companies are not precluded to evaluate and propose the results of these channels. |
| Intel | Agree with the FL proposal |
| Xiaomi | Agree with the proposal |
| Samsung | OK with Msg2/4 only. |
| Sharp | Our intention in the previous comment is supportive to evaluate SSB.Then we agree with DOCOMO’s comment. |
| Huawei, HiSilicon | Agree with the proposal |
| Panasonic | Fine with the proposal |
| MediaTek | Fine with the proposal, but we support the modification from DOCOMO and Ericsson. |
| Moderator  | The proposal is updated as follows.* **For initial access related channels, at least Msg2, Msg3, Msg4 and PDCCH scheduling Msg2/4 are included for link budget evaluation**
	+ **Other initial access related channels are not precluded**
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## Question 6

**Question 6: For target data rates, can the RedCap study reuse the same assumption in the CE study? If not, what modifications are needed?**

Regarding Question 6, most responses seem to agree that a lower downlink target data rates shall be assumed for RedCap UEs. The proposals by more than one individual response are the following

* 1Mbps in DL
	+ vivo, Sony, Intel (FR1), Sharp
* A single target data rate for all of FR1 and FR2
	+ FutureWei, Sequans
* Scaling the downlink data rate according to UE bandwidth capability and/or MIMO layer reduction, and modulation order restriction
	+ Sony, ZTE, Sanechips, Ericsson, Samsung, DOCOMO, Qualcomm, CMCC, Panasonic, CATT

For UL target data rates, some responses indicate to reuse the same assumption as in the CE SI, and a few responses propose to consider a different target data rate (e.g. 0.5Mbps in UL) for RedCap.

**Proposal 6: Adopt the following target data rates for link budget evaluation for FR1.**

* Urban: 1 Mbps on DL and 1 Mbps in UL
* Rural: 1 Mbps on DL and 100kbps in UL
* Note: UL target data rates are same as the CE SI

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| **Company** | **Comments** |
| DOCOMO | Agree with the proposal |
| Ericsson | We suggest adding clarification in the proposal that these are target data rates for RedCap UEs. |
| Qualcomm | For FR2, the following was the agreement for CE:BW = 100 MHz [400MHz]Adopt the following target data rates for eMBB performance evaluation for FR2.* Indoor: DL: 25Mbps, UL:5Mbps
* Urban: DL: 25Mbps, UL: 5Mbps
* Suburban: FFS: (DL: 1Mbps, UL: 50kbps)

For RedCap, the data rates defined in the SID:* Industrial Wireless Sensors: < 2 Mbps (UL heavy)
* Video surveillance camera: UL dominated, economic: 2-4 Mbps, high end: 7.5-25 Mbps
* Wearables: Ref DL / UL = 5-50 / 2-5 Mbps, peak DL / UL = up to 150 / 50 Mbps

As discussed in our paper, the reference bitrate given in the SID is a measure of median value across the entire cell thus not for cell edge UE. Therefore, the target data rates for RedCap coverage evaluation should be adjusted considering UE bandwidth reduction. One simple way is to scale the target data rates used in the CE SI by the reduced UE bandwidth.For 50 MHz BW, it may be reasonable to cut the CE rates by 1/2 with maximizing based on the SID requirements.For FR2, we suggest using the following (the rates in [] may be optional and refers to high end cameras)For 50MHz BW:* Indoor:
	+ Option A: DL: 12.5 Mbps, UL: 2 Mbps [12.5 Mbps]
	+ Option B: DL: 15 Mbps, UL: 2 Mbps [15 Mbps]
* Urban and Suburban: FFS

For 100 MHz BW: reuse the same values for CE SI, namely:* Indoor: DL: 25 Mbps, UL: 5 Mbps [15 Mbps]
* Urban and Suburban: FFS
 |
| vivo | We are fine with the FL proposal |
| CATT | We prefer to determine the target data rates for RedCap UEs by scaling the target data rates in by RedCap UE bandwidth. |
| ZTE,Sanechips | Agree with the proposal |
| CMCC | Fine with the proposal. |
| Intel | Agree with FL proposalFor Indoor FR2, we propose following target data rate for RedCap UE* DL: 20/10Mbps for BW 100/50MHz.
* UL: 5 Mbps
 |
| Xiaomi | OK with the proposal  |
| Samsung | OK |
| Sharp | Fine with the proposal. |
| Huawei, HiSilicon | In our view, the evaluated target data rate for link budget evaluation must consider the reference bitrate of RedCap use cases discussed in the revised SID, such as 5Mbps for PDSCH and 2Mbps for PUSCH at least in Urban scenario. 1 Mbps on DL and 1 Mbps in UL in Urban can not meet the requirements of the typical reference bitrate. We suggest adopting the following in FR1:* Urban: 5 Mbps in DL and 2 Mbps in UL
* Rural: 1 Mbps in DL and 100kbps in UL
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| Panasonic | We’d like to clarify a common understanding on how to determine the target data rates for RedCap SI. We propose to determine the target data rates for RedCap SI by scaling down the target data rates used in the CE SI under considering at least the reduced UE BW. Scaling ratio should be addressed first. This is applicable for both FR1 and FR2. |
| MediaTek | Fine with the proposal. |

## Question 10

**Question 10: For the impact of small form factor antenna on coverage, should the RedCap study consider the loss of antenna gain for all the uplink and downlink channels or only for the downlink channels?**

Regarding Question 10, most responses seem to agree to consider the loss of antenna gain due to small form factor for all the uplink and downlink channels.

**Alt. 1: All DL and UL channels**

* vivo, ZTE, Sanechips, Ericsson, Panasonic, Samsung, InterDigital, OPPO, DOCOMO, Lenovo, Motorola Mobility, Qualcomm, Sequans, CMCC, LG, Spreadtrum, Apple, Intel, Nokia, NSB, Huawei, HiSilicon, CATT

**Alt. 2: DL channels only**

* FutureWei

**Proposal 7: The impact of small form factor is considered for all the uplink and downlink channels**

* A 3dB loss of antenna gain is included in link budget calculation

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| **Company** | **Comments** |
| DOCOMO | Agree with the proposal |
| Ericsson | The antenna gain loss should be assumed only for UEs operating in FR1 FDD bands. Thus, we suggest adding “FR1 FDD” in the proposal. |
| vivo | We are fine with the FL proposal. The antenna loss is applied to both FDD and TDD bands.  |
| CATT | Fine with the proposal. |
| ZTE,Sanechips | Agree with the proposal |
| CMCC | Fine with the proposal. |
| Intel | Agree with the proposal |
| Xiaomi | OK with the proposal |
| Samsung | OK |
| Sharp | Fine with the proposal. |
| Huawei, HiSilicon | Agree with the proposal and the antenna gain loss should be assumed for RedCap wearable UEs operating in all FR1 bands. |
| Panasonic | Agree with the proposal. |

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