**3GPP TSG RAN#90e RP-20xxxx**

**e-Meeting, 7th – 11th December, 2020**

**Agenda item:** 9.1.1

**Source:** Nokia

**Title:** Moderator's summary for email discussion [90E][07][RedCap\_WI\_scoping] Initial round

**Document for:** Discussion/Decision

# Introduction

The documents considered as background to this discussion are listed in the references section at the end of this document. The deadline for comments in the initial round is 12:29 UTC on Tuesday 8th December.

# Initial Discussion

For the initial discussion round, we will focus on selected topics where there is the greatest need for convergence.

## Minimum number of supported Rx branches in FR1 TDD bands that currently support 4RX

There is currently strong support as well as strong opposition to allowing 1 Rx branch for this case. Form factor is the primary motivation cited by those in favour of 1 Rx branch, and there is clearly a strong feeling that there is a real market for such devices. On the other hand, strong concerns have been raised, citing the high coverage impact leading to a potentially unfeasible amount of specification work to be done as well as non-negligible network impact.

If devices with 1 Rx branch are to be supported, consensus would need to emerge on how this can be done in a way that addresses the concerns. Some possible compromises have already been mooted, including an upper frequency limit for 1 Rx, or higher antenna efficiency assumption for 1 Rx, for example.

In this section, companies are invited to propose ways forward. Please do not simply restate your preference for 1 Rx vs 2 Rx!

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| **Company** | **Proposed way forward** |
| T-Mobile USA | T-Mobile USA supports the proposed wording in RP-202701. As a way forward we would propose that TDD Bands that currently require 4Rx should require 2 Rx for RedCcap, and RedCap devices that can only support 1 Rx chain due to size or other constraints can use FDD bands. Operators deploying NR standalone need to be able to offer 5G enabled wearables. Without this change these devices are limited to LTE.  We share others’ concern that handheld devices should be required to meet the current RX antenna requirements. Enabling the ability to deny access to REDCAP devices adequately addresses this concern. |
| FUTUREWEI | As stated in our paper RP-202180, we have concerns on 1RX in these bands. Our biggest concerns are network impact and standardization impact. For a way forward, the network impact could be mitigated by including *now*, rather than postponing till after RAN2 study, the RAN2-led objectives on both RedCap UE types for identification/constraining and functionality for identification/restriction. In some cases the RAN2 decisions already say to resolve in the WI phase or wait for RAN1, in any case the objectives can be updated as needed after the next RAN meeting. For standardization impact, it is necessary to include *now* that there are no additional standardization impacts from including 1RX. Specifically, there are no PDCCH enhancements considered in RedCap. (Msg2/4 compensation should already be included in the WID for FR2, and exisiting techniques are sufficient for PDSCH.) The proposal on the GTW to not apply the 3dB penalty for 1RX may a a step also in the direction of making 1RX more acceptable. |
| Sierra Wireless | Sierra Wireless supports the current wording in RP-202701 as a way forward. Since the proposal supports 1 RX device for lower bands, use cases where devices are extremely size limited (e.g. wearables) can still be supported in a spectral efficient way. |
| CMCC | CMCC see it a compromise solution to mandate higher antenna efficiency for 1 Rx than that for 2Rx, which can guarantee 1 Rx and 2 Rx can achieve comparable coverage, and hence no special coverage recovery solution is needed. As to that it will scarify the dual layer transmsion in some sense, we have to admit that implementation reality and place some trust in our UE partners. |
| OPPO | For the coverage problem, it is clear that the case of potential problem is only in case of lower PSD (24dBm/MHz, which means very low for Macro Cell). For higher normal PSD, 1RX with all other possible loss will not results in coverage bottleneck in downlink.  Further, the concern of TDD coverage would be addressed by the access control of redcap UE.  Instead of complete disallow 1RX, which is only feasible for wearable, we should includes 1 RX. We can consider higher bandwidth as >4GHz, or as for higher antenna efficiency.  Addtionally, 1 RX or 2 RX can be used as differentiation of access control by NW side. |
| DOCOMO | We support 2Rx branches considering the coverage/scheduling impacts as stated in our contribution RP-202525. However, considering the divergent views among companies, we are also fine with the proposal from CMCC as a middleground, i.e., 1Rx without 3dB antenna efficiency loss. In this case, coverage recovery is not necessary other than Msg2, where existing TBS scaling is sufficient for the recovery of less than 3dB. |
| Intel | In our view, 2Rx is still the preferred option for RedCap UEs in bands in which a reference NR UE is required to support 4Rx.  However, if we follow the logic, that in such bands (> 2.496 GHz), 1Rx branch option offers easier and more efficient antenna designs, then, as also suggested by CMCC during the GTW session and seconded by DCM above, the “antenna gain loss” of up to 3 dB should not apply to Redcap UEs w/ 1Rx in such bands.  Thus, as a possible way forward, we propose that spec supports both 1Rx and 2Rx in bands > 2.496 GHz, with the consideration of “antenna gain loss” only limited to RedCap UEs with 2Rx.  In summary, we suggest the following:   * In FR1 bands ≤ 2.496 GHz,   + a RedCap UE is required to support 1Rx     - a UE may further report antenna gain loss of up to 3 dB in consideration of small form-factor constraints * In FR1 bands > 2.496 GHz,   + a RedCap UEs is required to support at least 1Rx     - Note: antenna gain loss, due to small form-factor constraints, is not considered   + a UE may optionally support 2Rx     - a UE may further report antenna gain loss of up to 3 dB in consideration of small form-factor constraints   On Futurewei’s comment regarding access restrictions and UE identification, we do not quite see how making a decision on WI scope for these now instead of at RAN1 #91-e changes anything w.r.t. mitigating impact to the network from 1Rx. As indicated below, we prefer to defer scoping of the RAN2-led objectives at RAN1#91-e *after* conclusion of the study in RAN2. |
| vivo | Technically the comparison between 1Rx and 2Rx has been extensively studied with the following key observations from the TR.   1. The following were observed from all three companies following RAN1 agreed traffic model (FTP model 3 for eMBB and IM model for RedCap) and scheduling BW assumption (100MHz for eMBB and 20MHz for RedCap)  |  | | --- | | *For burst traffic evaluation with IM traffic model for RedCap users:*   * *3 sources (Ericsson, Vivo, Qualcomm) observed that the RedCap users have minor or no impact on spectral efficiency and capacity, and little impact to the performance of co-existing eMBB users in the system* * *It is further noted that the 1 Rx RedCap users do not make an appreciable change on the user throughput performance of the eMBB users compared to the 2 Rx RedCap users* |  1. No coverage issue in FR1 for 1Rx UE for 4GHz with typical gNB PSD (33dBm/MHz) and any other FR1 TDD bands   Furthermore, during RAN1 studies, ideal assumption (low antenna correlation) was made for 2Rx case which is not realistic. For smart wearables, the compact device form factor will result in high Rx antenna correlations at the UE sides, thus large throughput degradation compared to the ideal antenna assumption (low correlation ensured by sufficient antenna spacing). In contribution “RP-202642 Performance issues with supporting 2Rx for wearables in FR1”, we evaluated the achievable performance for 2Rx with small antenna separation, which shows that the gain by 2Rx with high antenna correlations is marginal (less than 10%) compared to 1Rx.  According to the current situation, most of the LTE based smart wearables are equipped with 1Rx, even though the LTE specification does not support it. If this continues in NR, i.e. no 1Rx support in NR specification, we will repeat the same situation which means 3GPP specificaition does not provide a solution for smart waearables. In addition, there will be large amount of 1Rx devices in the market and the network which cannot be differentiated or identified by the operators, and there is no guarantee for the UE performance and consistency, which is our view the worst case, nobody will gain from that.  Based on the reasons above, 1Rx should be supported for FR1 TDD bands for wearable devices. We can accept the compromised proposal as raised by CMCC. |
| Spreadtrum | Firstly, as mentioned by companies, at least for wearables, due to form size limitation, 2 Rx may only bring small diversity gain.  Secondly, regarding the SLS results from one source, we share the similar observation of QC in RP-202746 that the upper bound of cell spectural efficiency reduction is 20% assuming the spectral efficiency of RedCap devices is 0.  Therefore, we support:  For FR1 TDD bands where a non-RedCap UE is required to be equipped with a minimum of 4 Rx branches, the minimum number of Rx branches supported by specification for a RedCap UE is 1. |

## Relaxed UE processing times (N1/N2)

On relaxed UE processing times, there seem to be a range of opinions and no evidence of consensus. Here, compromise proposals are invited, in case these could lead to an agreeable way forward.

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| **Company** | **Proposed way forward** |
| FUTUREWEI | No strong feeling here, if included it should be a second priority optional feature. |
| Sierra Wireless | Given the small cost savings and that the cost savings does not accumulate over bands, this feature should be consider later after other higher priority features are agreed. |
| CMCC | No, if redcap UE definitely require relaxed UE processing times, which may means all the existing gNB need to upgrade (different Rx number and layer number is not new to the network) if redcap UEs ared introduced to network even some of those gNB have already provided quite good coverage. Without relaxation, operators at least not necessarily need to upgrade the initial access procedue for some gNBs. |
| OPPO | We suggest to support it with simple scope, e.g. define doubled Ns. |
| Intel | We believe relaxing UE processing times can provide meaningful reduction to UE implementation *complexity* and *cost,* and, at around doubled the Cap #1 values, are sufficient for RedCap use-cases.  Note that only the *cost* aspect has been quantitatively evaluated so far during the SI, and seen to facilitate about 7% savings in cost. However, the rather complex NR baseband procedures, with a significant majority of them subject to tight timelines defined by the min. UE processing times N1/N2, puts a strain on the overall baseband design complications that go beyond BoM.  One of the concerns regarding introduction of relaxed N1/N2 has been on UE identificaiton. In this regard, it should be noted that early identification of RedCap UE type(s) is necessary to address coverage recovery for Msg3 in FR1, and potentially for PDCCH CSS and Msg4 in FR2, and a single mechanism for early RedCap UE identification to address both coverage recovery and relaxed N1/N2 becomes the most straightforward option.  Lastly, in terms of increasing complexity at gNB scheduler, it should be noted that a Rel-15 gNB is already dimensioned to handle numerous different minimum processing timelines for different PHY layer procedures due to the presence of many special handling and additional scenario- and configuration-specific margins. Thus, we do not see the introduction of a relaxed timeline causing any significant additional complexity to gNB scheduling, especially considering that the new timeline is a *relaxed* timeline (with the possibility of leveraging the relaxation at the gNB side as well). |
| vivo | Based on the RAN1 study, the overall cost reduction by relaxed processing time is limited, ~5%. However, we expect some power saving benefit since UE can lower the clock rate and voltage. Therefore, if relaxed UE processing time is to be considered further, we think the initial access procedure shall not be impacted, i.e. UE support Rel-15/16 processing time during initial access procedure and can operate with slower processing time after RRC connection completion and only for large TBS or resource allocation. |
| Spreadtrum | Similar views with Sierra Wireless, this feature can be consider later. |
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## Reduced PDCCH monitoring

There appears to be strong support for reduced PDCCH monitoring, with the main support being for “Scheme #1” (reduced maximum number of Blind Decoding (BD) per slot in connected mode).

It seems reasonable, therefore, to focus the discussion here on Scheme #1.

What is not clear, however, is what needs to be specified specifically in the RedCap WI, compared to what has already been specified in R16 power saving and what is being addressed in the R17 power saving WI. If RedCap-specific aspects are seen useful, companies are invited to explain here the details of what should be included in the RedCap WID and why it needs to be specific to RedCap.

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| **Company** | **RedCap-specific aspects of reduced PDCCH monitoring Scheme #1** |
| T-Mobile USA | Best place to address this issue is in the power saving WID. |
| FUTUREWEI | No strong feeling here, if included we prefer to focus on scheme #1 targeting no increase of the blocking rate. If this can be done without new specification impact then it will be a quick objective in the WG. |
| Sierra Wireless | This feature should be added to the power saving WID, assuming it fits within TU budget. There is no clear reason why this would be done in the RedCAP Wi and conducting power saving work within two work items is not efficient. |
| CMCC | More belong to power saving WID. |
| OPPO | We suggest to include the scheme with directly reduced blind decodes by half for RedCap UE. This will have very minor spec impact and achieve simplication of implementation. |
| DOCOMO | We don’t support Scheme#1 considering the limited power saving gain while PDCCH blocking rate is not negligible. Also, the power saving gain by BD reduction can be achieved by existing Rel.15/16 CORESET/search space set RRC configurations. If majority companies would support the feature, we suggest to consider the compromised proposal from moderator in the last RAN1 meeting, i.e., *PDCCH monitoring reduction scheme(s) to obtain smaller BD numbers, with target for zero increment PDCCH blocking rate in Rel-17 to avoid the network scheduling impact*, as the middleground. |
| Intel | Scheme #1 should be specified with normative work in RedCap WI primarily involving:   * specifying a new set of limits for required numbers of BDs per slot for RedCap UEs such that the new limits are approximately half of Rel-15 limits, and * possibly also specifying a reduced number of DCI format sizes a RedCap UE is expected to support.   These objectives are not covered by UE PS Enh. WI, and should be defined as part of RedCap WI.  It is important to note that these are objectives that not only help in UE power savings and do not have any significant adverse impact on PDCCH blocking in any reasonable configuration, but they also allow for a more appropriate dimensioning (*complexity)* of RedCap UEs considering their target use-cases. |
| vivo | The power saving benefit and system impact (PDCCH blocking rate) has been extensively studied in RAN1. With reasonable AL distribution and number of co-scheduled UEs, the blocking rate is marinal with 50% BD reduction. Therefore we support to include at least schme#1 in the WI for power saving. |
| Spreadtrum | To implement “Scheme #1” in the spec, DCI format(s) with compact DCI size can be supported by RedCap UE. Nevertheless, the compact DCI size is beneficial for coverage recovery of PDCCH CSS for RedCap UE. |

## Early identification of RedCap UEs

Early identification of RedCap UEs is clearly seen as being strongly necessary. If there are specific proposals that could be agreeable to refine the scope of the WI objective for this, companies are invited to propose them here:

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| **Company** | **Potentially agreeable proposals to refine the scope of the WI objective for identification of RedCap UEs** |
| T-Mobile USA | The use of UE categories or any horse of a different colour would not be supported by T-Mobile USA in achieving this objective. |
| FUTUREWEI | We support “Early identification in Msg 1 is supported for at least some RedCap UEs” as a subbullet of “Specify functionality that will allow RedCap UEs to be explicitly identifiable to networks and network operators and allow operators to restrict their access.”  Note that the language intentionally does not say “RedCap UE types” as type discussion is ongoing in RAN1 and RAN2. If needed we can add a note that supporting early identification is not the same as introducing UE categories (we are not in favor of introducing UE categories in NR). |
| Sierra Wireless | There doesn’t need to be a specific objective on early identification. The WGs can decide if early ID is needed (will depend on features) and the best solution (msg1,msg3 or msg5). Plenary should not recommend a solution.  There is also no need to specify UE categories. We only need to define optional UE capabilities for the cost reduction techniques but this doesn’t need to be capture in WID – its business as usual. So no need for this bullet: “o Specify definition of RedCap UE type(s) including set(s) of L1 capabilities at least for RedCap UE identification and for constraining those UEs to the intended use cases.”  There is however, a need for this bullet:” o Specify functionality that will allow RedCap UEs to be explicitly identifiable to networks and network operators and allow operators to restrict their access.” If there is a need to restrict access before UE capabilies (Msg5) are exchanged, this would be good to specify here. |
| CMCC | Earlier identification should be decoupled with special UE capability, decoupled with reacap UE, at least it should not be mandatory requirements for the network to serve the redcap UE. |
| OPPO | We see both early identification by Msg 1 and 3 for some RedCap UEs could be the sub-bullet. |
| DOCOMO | We support early identification during Msg1 as coverage recovery for Msg2/3 may be necessary, depending on the discussion in Section 2.1. However, this can be confirmed after RAN2 SI completion. |
| Intel | While not necessarily against the proposal on early identification itself. We have concerns from a procedural perspective to define WI objectives for RAN2-led items while the studies are still ongoing in RAN WG2. Thus, we would prefer to come back to all RAN2-led items at RAN #91-e. |
| vivo | Technically, although RAN1 and RAN2 had heavlily discussed the early identification (e.g. msg1 or msg3 based) , however, there is no conclusion about its necessity.  From procedure perspective, the study item is still ongoning in RAN2, any RAN2 involved topic shall not be included in the WID for this meeting. |

## Other points

There seems to be strong support for HD-FDD type A.

**Moderator’s proposal: HD-FDD type A is supported**

Coverage compensation will be further discussed after the conclusion of the number of UE Rx branches in section 2.1. Work on coverage recovery aspects could be deferred until after RAN#91e in order to be able to assess the reusability of the work done in the Coverage Enhancement WI.

For the supported bandwidth after initial access, very heavy discussion has already taken place in RAN1, and, from the RAN plenary tdocs, there seems no evidence of a different consensus now emerging compared to what is in the current draft WID [18].

In other topics, there does not seem to be evidence of majority support going in a different direction from what is in the current draft WID [18].

If there are important comments on the above or other points, companies may state them here.

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| **Company** | **Other important comments** |
| FUTUREWEI | We do not think half-duplex should be directly proposed as agreed without further discussion. Issues include: (1) not applicable to TDD bands, (2) RAN1 could not agree on whether the existing specifications could be reused or not. Similar to processing time reduction, if in the end it is included it should be a second priority optional feature.  Coverage compensation is best not to leave open. RedCap should include what is needed for RedCap in RedCap. Whether and how RedCap UEs use Rel-17 CovEnh features (and existing Rel-15/16 features that help coverage) is discussed later along with RedCap UE capabilities.  The current draft WID mentions 3dB for PUSCH/Msg 3, which does not include the new proposal from GTW to not include this factor for 1RX. The labguage in the draft would need tobe revised as it prioritizes the CE WI over existing techniques from Rel-15/16.  The draft needs to include PDSCH/Msg2/Msg4 where the SI shows that some coverage enhancement is needed for FR2 for the 100MHz 1RX case for 23dBm UEs. (Note1: this is *not* dependent on the 4RX to 1RX question in section 2.1. Note2: PDSCH/Msg2/Msg4 are not included in the draft CE WID.)  The current WID is prefered for bandwidth after initial access to avoid repeated discussions. |
| Sierra Wireless | Agreed that HD-FDD type A shall be supported but scope needs to be considered.  Having two Wis (RedCap & CovEnh) doing coverage enhancement is extremely inefficient – we saw this in the SI phase. The RedCAP SI did not agree on techniques for coverage enhance only targets so at best this would be another study of techniques to meet a target. Thus: all coverage related work should be done in CovEnh WI including Msg3 coverage enhancement. Given 1RX in high TDD bands is not support, there should be no need to do coverage enhancement for FR1 DL channels. The enhancements for FR2 DL should also be include in the CovEnh WI.  We see the option of increasing bandwidth after initial access beyond 20MHz as low priority. |
| CMCC | Not urgent |
| OPPO | RAN1 conclude to make FR1 other than 20MHz as FFS:   * + Whether an FR1 RedCap UE can optionally support a maximum bandwidth larger than 20 MHz after initial access   We can forward the discussion in WI phase.  Type A HF can be support. |
| Intel | We are supportive of the moderator proposal on Type A HD-FDD.  On coverage recovery, we would need to resolve any overlaps with CE WI as part of this discussion thread.  Further, even if any of the solutions are reused between RedCap and CE, the details of the procedures and their applicability to RedCap UEs need to be discussed under RedCap WI.  Towards this, as a first step, we should at least decide on high-level scoping of the targets this week, e.g., which channels are candidates for recovery in FR1 (considering “below 2496 MHz” and “above 2496 MHz”) and in FR2, etc.   * For instance, we hope to confirm that for FR1 bands <= 2496 MHz, coverage recovery mechanisms (targeting up to 3 dB) will be specified for RedCap UEs. * Similarly, for FR2, whether to pursue coverage recovery for PDCCH CSS and Msg4 in consideration of deployments with 23 dBm UEs (which we support). * For FR1 bands > 2496 MHz, we agree that this depends on resolution of the # of Rx branches in Section 2.1. |
| vivo | We are fine to not support HD-FDD in Rel-17.  For coverage recovery, our view is that   * UL coverage recovery for PUSCH and MSG3 are justified in both coverage enh SI and redcap SI, there fore can be included in coverage enh WI for a common solution across difffernt UE types (eMBB and RedCap) with the consideration of potential 3dB antenna efficiencly loss for RedCap UEs. * There is no strong justification for DL coverage recovery even with 1Rx UEs, since no coverage issue has been identified for 4GHz band for typical gNB PSD (33dBm/MHz) and any other FR1 bands or FR2. Therefore we prefer to not have any DL coverage compensation specifically for RedCap UEs. |
| Spreadtrum | Agree with moderator’s proposal: HD-FDD type A is supported  For coverage recovery, we should follow RAN1 observation to include the coverage recovery in WI scope:   * For RedCap UE with 1 Rx and reduced antenna efficiency, dependent on frequency bands and the assumption of DL PSD, the need for coverage recovery can be different   + For carrier frequency of 4 GHz with DL PSD 24 dBm/MHz, coverage recovery may be needed for the downlink channels of Msg2, Msg4 and PDCCH CSS. A small or moderate compensation can be considered:     - [1 dB] for PDCCH CSS     - [2-3 dB] for Msg4     - [5-6 dB] for Msg2 without TBS scaling. It is noted that coverage loss for Msg2 can be compensated by using the existing TBS scaling technique. |
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# Company contact details

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# References

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2. RP 202268 Scope of Rel-17 WI on support of reduced capability NR devices Huawei, HiSilicon
3. RP 202303 Discussion on WI scope of RedCap device OPPO
4. RP 202323 Views on the scope of RedCap WID CMCC
5. RP 202346 Motivation for Reduced Capability NR devices WID Sierra Wireless, S.A.
6. RP 202353 Views on Reduced Capability NR device WI Intel Corporation
7. RP 202355 On overlapping objectives across Rel-17 WIs Intel Corporation
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9. RP 202531 On the scope of Rel-17 reduced capability NR devices Samsung
10. RP 202550 Views on Reduced Capability NR devices Xiaomi Technology
11. RP 202560 On the open issues for support of Redcap NR devices Apple Inc.
12. RP 202637 Views on WID scope for Rel-17 RedCap vivo
13. RP 202642 Performance issues with supporting 2Rx for wearables in FR1 vivo
14. RP 202667 On WI scope of support of reduced capability NR devices ZTE, Sanechips
15. RP 202693 Discussion on WI scope for RedCap NR devices MediaTek Inc.
16. RP 202712 Views on support of reduced capability NR devices in Rel-17 CATT
17. RP 202696 Scope of RedCap WI Nokia, Nokia Shanghai Bell
18. RP 202701 New WID on support of reduced capability NR devices Ericsson
19. RP 202702 Motivation for New WI on support of reduced capability NR devices Ericsson
20. RP 202746 Views on scope of NR RedCap WI Qualcomm Incorporated