**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] Intermediate 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.

# Summary of Initial Discussion, and topics for intermediate discussion

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

The significant support and significant concerns for 1 Rx remain.

However, the proposal to mandate a 3dB higher antenna efficiency for 1 Rx UEs seems an acceptable way forward to a large majority of companies. It should be noted that TDD bands below 2496MHz currently require only 2 Rx for non-RedCap UEs, so the discussion here focuses only on bands above 2496MHz.

The challenge remains how to specify this, though, as only conducted tests exist in RAN4 currently, with a couple of companies mentioning the need for OTA requirements.

Constructive comments are therefore invited on the following:

**Moderator’s proposal 1:**

* In FR1 TDD bands that currently require support of 4Rx,
	+ A RedCap UE may support 1 or 2 Rx
	+ Only if supporting 2 Rx, a reduction of 3dB in antenna gain is permitted
	+ Network identification of 1 Rx UEs shall be supported
* RAN4 to specify OTA requirements for 1 Rx and 2 Rx RedCap UEs in FR1 above 2496 MHz, requiring 3dB more antenna gain for 1 Rx than for 2 Rx.

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| **Company** | **Comments on moderator’s proposal 1** |
| Ericsson | Given the operator input on the RAN reflector, we prefer to not support 1 Rx in bands that currently require support of 4 Rx. |
| Huawei, HiSilicon | We can support the main parts of this proposal.However, there is not a need for “network identification” of 1 Rx UEs, because now there is no difference in the random access procedure between 1 Rx and 2 Rx UEs’ antenna gain. The difference can be reported by capability, for scheduling use after initial access.What is needed is *access barring* (refered to in the draft WID as access restriction, as distinct from identification), so that a concerned operator can prevent the UEs from accessing the network.It may not have to be OTA testing requirements, if there are concerns – though it is possible RAN4 can overcome them anyway. It could be a limitation on the MCS (or similar) that requirements would be set for 1 Rx, meaning that they would be required to demodulate at higher MCS than 2 Rx, and this would serve to prevent a high resource consumption, which may also go towards addressing a point made on the reflector of maximum number of PRBs for reduced Rx branches.An alternative is to set RAN4 the more general task of working out how to make 1 Rx and 2 Rx equivalent in terms of antenna performance in RedCap UEs. |
| CMCC | Generally, we are fine with the proposal, however, from our understanding, Network should necessarily identify the 1 Rx UE if the network is unwilling to serve kind of UE,which could be resolved by some access control mechanism. Then this kind of UE can be totally igonored by the network. So would like to propose to add one objective: support access control mechanism to prevent xxx UE from accessing the network. |
| T-Mobile USA | T-Mobile USA has concerns with 1 RX for TDD bands, REDCAP UE’s for TDD bands should be required to support a minimum of 2 RX chains. Also there needs to be another objective for FR1 FDD bands that states * In FR1 FDD bands that currently require support of 2 Rx,
	+ A RedCap UE may support 1 Rx

Lastly OTA requirements haven’t been defined and as past experience has shown developing OTA requirements is very difficult. RAN4 had difficulty defining TIS requirements for LTE simply because operators have varying requirements based on how the band is used in their network.  |
| Intel | Our first preference is still aligned with that of Ericsson and operators, that is to only limit to 2Rx UEs in bands > 2496 MHz.However, for the sake of progress, we could compromise to the proposal limiting the antenna gain loss to 2Rx UEs only. However, we have couple of comments on the proposal as it may not be entirely accurate/clear in its current form:1. Top-level bullet “*In FR1 TDD bands that currently require support of 4Rx*”:
	* These bands are not necessarily “TDD bands”; there are FDD bands with 4Rx requirements in FR1 bands > 2496 MHz. So, a more appropriate description would be to say “In FR1 bands above 2496 MHz,” (“that currently require support of 4Rx”) can be removed as it then becomes redundant.
2. “*Network identification of 1 Rx UEs shall be supported*”
	* We would like to clarify that this does not necessarily imply that the identification has to be during initial access. Such identification can be realized even as part of UE capability reporting (please see our response to proposal in Section 2.4).
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| Sierra Wireless | As mentioned by moderator, there is likely no way in RAN4 specification to implement the last bullet so this is not a feasible compromise. 1 RX UE should be limited to lower bands (e.g. FDD/TDD bands below 2496MHz) which are the bands which provide coverage. As Vodafone stated, a wearable will anyway need to support lower frequency bands to be able to operate widely, so could support 1 Rx. Net: a 1 RX wearable is possible. As a compromise, the current limit of 2496MHz could be raised to [3600] MHz to include some lower TDD bands but no coverage enhancement work should be add to WI as a result of this objective. |
| Apple  | We support the first bullet and its sub-bullet except the 2nd one (i.e. ‘Only if supporting 2 Rx, a reduction of 3dB in antenna gain is permitted’). Instead, we propose to add the following sub-bullet to explicitly address the concern on 1 Rx branches in terms of specification efforts: * No extra optimization in coverage recovery for 1 Rx device in FR1 above 2496MHz.

We do not see the need of 2nd main bullet. The OTA requirement for Redcap UE should be separate discussion and not coupled with the support of 1 Rx. As long as no extra covery recovery scheme would be introduced for 1 Rx device, the concern on coverage should be addressed already. In summary, the following was proposed: * In FR1 TDD bands that currently require support of 4Rx,
	+ A RedCap UE may support 1 or 2 Rx
	+ Network identification of 1 Rx UEs shall be supported
	+ No extra optimization in coverage recovery for 1 Rx device in FR1 above 2496MHz.
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| DOCOMO | Similar to Intel, our first preference is supporting 2 Rx branches. For the sake of progress, we are fine with the proposal. If specifying the OTA requirements is not acceptable, alternative proposal from Huawei can be considered as well. |

## Relaxed UE processing times (N1/N2)

A clear majority of companies do not support relaxation of UE processing times, mainly due to perceived limited cost/complexity saving and additional network complexity. A few companies suggested “simple” relaxations, such as doubling processing times, and several saw this as a low priority feature or even for the next release. Among the few proponents, power saving gains were mentioned, and the possibility of treating this as an optional capability.

In the light of this landscape, the **moderator’s conclusion** is that relaxed UE processing times are not included in the WID.

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| **Company** | **Comments on moderator’s conclusion** |
| Huawei, HiSilicon | We do not think the WID is complete without relaxation of processing times, because the complexity saving is clear, and under-estimated by RAN1.Such a UE can be found through early identification, or barred by the similar access restriction as is proposed for 1 Rx UEs.Further compromise suggestion: within the early identification, that it is applied only from Msg3 for relaxed processing time, which would help alleviate concerns over the potential impact to initial access. This is in addition to access control. |
| CMCC | Yes, processing time relaxed for redcap UE should not be supported |
| T-Mobile USA | Power savings is minimal, this objective should be excluded from the WID |
| Intel | We share similar view as Huawei here – the complexity saving has been under-estimated due to reliance on a “cost-based” analysis that is somewhat limited to a BoM-based cost estimation. Thus, as described before, we still think relaxation of min. UE processing times should be introduced for RedCap UEs to enable low complexity implementations that are critical for the success of RedCap. We are open to the compromise of supporting relaxed processing times and Cap #1 as UE-optional capabilities for RedCap UEs. We observe that such a compromise has been suggested also by several other companies. Hope this can be taken into account. |
| DOCOMO | We support the proposed conclusion. |
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## Reduced PDCCH monitoring

Roughly half the companies prefer not to handle reduced PDCCH monitoring in this work item.

Among the companies in favour of including reduced PDCCH monitoring, several emphasised the need for reduced DCI size in order to avoid increasing the PDCCH blocking rate.

A possible way forward could perhaps be to add the following “second priority” objective to the WID. Comments on this are invited.

**Moderator’s proposal 2:**

A reduction of the maximum number of BDs per slot in connected mode can be considered with second priority, if time permits after the DCI sizes have been finalised, within the constraint of not increasing the PDCCH blocking rate.

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| **Company** | **Comments on moderator’s proposal 2** |
| Ericsson | We still do not see reduced PDCCH monitoring can be justified to be considered with second priority. The benefit in UE power saving is too insignificant. RAN2 is studying additional UE power saving features, and we expect the RAN2 features will provide more significant benefits. So we think at least we should wait for the completion of the RAN2 study to decide which power saving features need to be prioritized in the RedCap WI. That being said, since only about half of the companies expressed support for reduced PDCCH monitoring in the initial round of this email discussion, it seems fair to say that there is no consensus for it. |
| Huawei, HiSilicon | DCI sizes are traditionally known at the very end of the release, or at least very late-on, so we think this approach is likely to lead to a race condition and difficult discussions in RAN1. It would be cleaner to say such as:*A reduction of the maximum number of BDs per slot in connected mode can be considered with second priority, if ~~time permits after the~~ DCI size(s) have been reduced ~~finalised~~, within the constraint of not increasing the PDCCH blocking rate.*Then the RAN1 chair will be able to guide in due course as to when second priority comes up. |
| T-Mobile USA | R16 UE Power saving techniques should apply to RedCap UE’s.  |
| Intel | The qualifier “if time permits after the DCI sizes have been finalised” is not necessary, especially if we add “with second priority”, which in itself is something we do not prefer to say, but can compromise to for the sake of progress.It is not clear what relevance there is to DCI format sizes – it is not even clear if there is any need to define any new DCI formats for RedCap compared to Rel-15/16, and thus, even less clear what is meant by “after the DCI sizes have been finalized”. The suggested modification from Huawei is not clear. There is no need identified so far to reduce DCI format sizes, but rather there was a proposal to reduce the “DCI format size ***budget***”. We are supportive of that objective, but not to define the basic BD limit reduction objective to be conditioned on the reduction in the DCI format size budget. This is captured in the green text below.The last part on “constraint of not increasing the PDCCH blocking rate” is neither necessary nor accurate in reducing the max # of BDs per slot. If max # of BDs per slot is reduced, there will certainly be some weird/impractical combinations of configurations of system resources and PDCCH loading that can lead to increased PDCCH blocking. Essentially, these are configurations with very small PDCCH resources relative to the PDCCH load. In such cases, even Rel-15 capabilities lead to high (e.g., > 20%) blocking rate. However, such examples are irrelevant in practice and should not be considered. Lastly, the phrase “in connected mode” should be removed since the reduced limits should be applicable for the UE, irrespective of RRC connection status.In summary, we suggest the below modification:*A reduction of the maximum number of BDs per slot ~~in connected mode~~ and a reduction in the DCI format size budget can be considered with second priority~~, if time permits after the DCI sizes have been finalised, within the constraint of not increasing the PDCCH blocking rate~~.*  |
| Sierra Wireless | We are still not sure the gains are justified here but if they are, this work should be added to Power Saving WID, not in RedCAP WID. As Ericsson mentions, RAN2 is studying additional UE power saving features which seem to provide more benefits than this. |
| Apple  | We do not see the connection between ‘DCI sizes’ and ‘maximum number of BD reduction’. One of solutions under scheme #1 is to reduce the DCI size budget i.e. ‘3+1’ to ‘X+1’ where X<3 e.g. X=2. This can be achieved by introducing DCI size alignment and generally is irrelevant to Rel-17 DCI designs unless the ‘3+1’ DCI size budget would be modified in Rel-17. Even that, the concept of reduced DCI size budget is still valid and can be used to reduce the maximum number of BDs for Redcap devices by further aligning the sizes of configured DCI formats.  |
| DOCOMO | We share the view with Ericsson |
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## Early identification of RedCap UEs

Early identification (e.g. msg 1 or 3) is clearly seen as an important component of addressing network operators’ concerns about the impact of RedCap devices in their networks. On the other hand, several companies pointed out that the RAN2 study is still ongoing, so it is too early to be explicit as to the mechanism. It was also emphasised by a couple of companies that UE “categories” should not be introduced.

A comment was also raised as to whether any specific difference is intended between “networks” and “network operators” here. It is the moderator’s view that no difference is intended, and one solution could be to delete “networks and”.

Hence, comments are invited on the following suggested update to the WID:

**Moderator’s proposal 3:**

* + Specify functionality that will allow RedCap UEs and 1 Rx RedCap UEs to be explicitly identifiable to network operators during initial access and allow operators to restrict their access. The details of identification (e.g. by means of msg 1 or msg 3) will be determined by RAN#91e.

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| **Company** | **Comments on moderator’s proposal 3** |
| Ericsson | Perhaps the words “during initial access” can be removed. Operators should be able to identify RedCap UEs and restrict the access if needed, but the exact solutions can be developed in the WGs. It is already suggested in the proposal that the identification might be in Msg1 or Msg3, and we will know the overall picture better when the WID is revised in March after the RAN2 part of the SI has been finished. |
| Huawei, HiSilicon | It may be a misunderstanding that early identification of 1 Rx UEs is still needed when they can have the same antenna gain as 2 Rx UEs. The point of early identification is to allow differential handling of the UEs during the initial access procedure. Capability reporting is then used to deal with the difference after initial access. In ‘regular’ NR, UEs are assumed as 1 Rx during initial access, due to the absence of capability information.What is needed is the ability for the network to restrict access by 1 Rx UEs in the first place, and this should start to relieve operator concerns. |
| CMCC | No supporting early identification of special UE. the UE can be barred from the network based on access control mechanism, which can avoid initial access procedure. In our understanding, early identification will force some of the gNBs upgrade too much even they have already provided good coverge, for these gNBs, no special mechanism is needed to accommodate the redcap UE. if from the PDCCH efficiency point of view, the early identification will be only used for identification of the pathloss rathter than for redcap UE, since anyway, some redcap UE may be close to the gNB, which require no more CCE. |
| T-Mobile USA | We agree with Ericsson’s and CMCC’s comments, Unified access control is another way to prevent RedCap UE’s from accessing the network. RAN2 needs to discuss the point at which UE’s are barred and their criteria for barring doesn’t need to be based on the number of antennae. For single antenna UE’s the capacity impact is very small if there are barred because they are only on the network for a very short period of time. |
| Intel | While we are fine with the intention of the proposal, our preference was to defer this objective until RAN #91-e. However, if this helps assuage operators’ concerns, we can accept a high-level description of such an objective, although the current formulation could indeed cause some misunderstanding. In FR2 bands and FR1 bands ≤ 2496 MHz, all RedCap UEs would be required to support only 1Rx. Per Section 2.1, we are only considering RedCap UEs with 1Rx and 2Rx in FR1 bands > 2496 MHz, and between these two potential RedCap UE types. Then, the key distinction boils down to whether “antenna gain loss” can be reported by the UE (we do not think such “loss” should be the default for RedCap UEs as there are many RedCap use-cases w/o any form-factor constraints and their performance should not be compromised). So, we have three types of UEs in FR1 bands > 2496 MHz:* Non-RedCap UEs
* RedCap UEs w/ antenna gain loss (permitted only for 2Rx UEs)
* RedCap UEs w/o antenna gain loss (1Rx and 2Rx UEs)
	+ *The distintion between these two sub-types can be realized during UE capability reporting.*

Thus, the key factors that could require “early identification” are *at least*: (i) if coverage recovery may be necessary for Msg3 or not, and (ii) for support of relaxed min. UE processing times. We are also supportive of early identification between RedCap and non-RedCap UEs. Thus, the early identification could be characterized by something like: “*Specify functionality that will allow RedCap UEs and ~~and~~ ~~1 Rx RedCap UEs~~ RedCap UEs with additional antenna gain loss and/or relaxed minimum UE processing times, to be explicitly identifiable to network operators …*”. |
| Sierra Wireless | On the right track but don’t think the second sentence is need because RAN1/2 can determine the correct restriction and identification solutions. If the second sentence is kept then I would strongly prefer to remove “(e.g. by means of msg 1 or msg 3)” as e.g. have caused lots of issues and confusion in WG in the past.  |
| Apple  | The proposal is not very clear for us. As one example, the first ‘Redcap UEs’ supported to include ‘1 Rx Redcap UEs’ as well. In addition, the motivation to earlier identification of ‘1 Rx’ and ‘2 Rx’ Redcap devices is unclear for us assuming there is no extra DL coverage recovery targeting for 1 Rx device as compromise WF. After initial access phase, 1 Rx or 2 Rx can be reported as part of UE capability as usual.  |
| DOCOMO | We prefer to defer this discussion to RAN#91e as it is RAN2-led item and there are a number of uncertain aspects, such as whether to support both 1 and 2 Rx branchs for FR1 TDD bands with/without antenna efficiency loss and whether to support relaxed UE processing times. |

## Other points

A clear majority of respondants agreed with the proposal to include support of HD-FDD type A.

The **moderator’s conclusion** is therefore to confirm this proposal.

## Coverage recovery

In the light of the proposal in section 2.1 and the comments made in the initial round, it would appear that the UL coverage recovery should be able to be covered by the Coverage Enhancement WI, while DL coverage recovery would not be needed due to the increased antenna gain for 1 Rx UEs. It was also mentioned that overlap between WIs should be avoided.

Comments are therefore invited on the following:

**Moderator’s proposal 4:**

Delete the objective “Specify coverage recovery …” from the WID.

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| **Company** | **Comments on moderator’s proposal 4** |
| Ericsson | There should at least be a RedCap WI objective on verifying that the relevant solutions from the CE WI can be used for RedCap coverage recovery. |
| T-Mobile USA | We agree with Ericsson’s comment |
| Intel | Agree with Ericsson. To repeat our previous comment, while it is fine that the basic mechanism is defined in CE WI, but the exact solution for RedCap, including details of UE behavior, should be defined in RedCap WI. This is because: (1) the targets are different (for RedCap, it is limited to 3 dB to compensate for antenna gain loss, while for CE WI, it is “coverage enhancement”); (2) the applicability would likely be different; and (3) the relationship to RedCap UE early identification can be different compared to handling in CE WI that deals with non-RedCap UEs supporting CE features. Thus, the objective on coverage recovery should be present in RedCap WID.  |
| Sierra Wireless | Agree with moderators suggestion. I don’t think a “verification” objective is very useful – where would such a verification be documented – this is not a study.  |
| DOCOMO | We agree with Ericsson and Intel. |
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# Annex A: Initial Discussion

## 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)

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| *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*
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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. |
| Apple | As explained in our paper RP-202560, reducing the number of Rx branches to 1 for TDD bands brings additional 15% cost reduction. More importantly, it enables NR support for wearable device with a small form factor. As we noted in paper, reducing to 1 Rx do NOT cause any coverage problem for normal DL PSD case as it still has better coverage performance than that of referenc channel i.e. PUSCH of normal NR devices. Hence, coverage loss is NOT real concern for 1 Rx branch. On the other hand, following moderator guideline, one compromised way forward we can consider is to support both 1 Rx and 2 Rx branches for TDD band that currently requires 4 Rx branches. Correspondingly, framework of access management, including early identification and access control can be studied for these two Rx branch configurations in work item phase to address the operator’s concern on network efficiency impact.  |
| CATT | As discussed in our paper RP-202712, we prefer 2 Rx due to the negative impact on network spectial effiecency, capacity and coverage of 1 Rx. However, considering the strong need of 1 Rx from UE implementation perspective, we are fine with the compromised proposal from CMCC. |
| Samsung | Due to the limited form factor of wearables, i.e. watches, it cannot support 2 Rx branches for low band. Even two Rx branches can be placed on, we share similar observations in RP-202642 and RP-202746 that it cannot improve network efficiency due to the lack of antenna isolation and high correlations. On the other hand, it will increase the cost, size, and power consumption of wearables devices, which is against the goal of this SI/WI. Regarding on the network performance impact, for burst traffic, there is minor or no impact and no appreciable change on eMBB users:TR 38.875*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*

For the case of burst traffic evaluation with FTP model 3 for RedCap users, the observations are opposite due to different simulation settings:*100MHz system bandwidth comprises five frequency blocks of 20MHz. Scheduled within one frequency block for both eMBB UE and RedCap UE*Also, we share similar view in RP-202746 that cell spectral efficiency loss is upper bounded by 20% in the above simulation setting. It is a pity that RAN 1 cannot make agreeable conclusion, however, we believe that the capacity loss shown can be eliminated with a proper setting. We can understand that operators want to make sure there is no negative impact to the eMBB devices in the network - access barring for particular UE type/capability can be used by the network as needed. Therefore, we think support of 1 Rx with access barring explicitly states in the WID can be a good comprisme. In the meanwhile, we can live with 2Rx can be optional supported for Redcap for the band mandatory support 4 Rx for regular NR UE.  |
| DISH Network | For TDD bands, as a bare minimum both 1RX and 2RX requirements should be defined. Further discussion on the details is needed during this week. |
| Ericsson | We think a reduction from 4 Rx to 2 Rx is a reasonable compromise considering the wearable market requirement and network impact. For the sake of progress, we will be fine to accept 1 Rx with an upper frequency limit or with a higher antenna efficiency assumption.The moderator’s question concerns FR1 TDD bands. But, we want to point out that there are also some FR1 FDD bands where 4 Rx branches are currently required. Thus, the way-forward probably should apply to all FR1 bands that currently require 4 Rx branches. |
| ZTE | For compromise, we propose to support both 1 Rx and 2 Rx by specification.“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 N=1, where N=2 is also supported in the spec.”If coverage is a concern, we are open to consider coverage enhancement technqiues for DL channels in the CE WI and discuss whether these techniques are mandatory for these 1Rx RedCap UEs. RAN4 can decide to specify to support N=2 Rx RedCap UEs in the band(s) still with high coverage impact or RAN4 can define requirements based on the assumption with higher antenna efficiency.  |
| Xiaomi | For the coverage loss, as observed in the TR, only the broadcast PDCCH, Msg.2 and Msg.4 would be impacted. For Msg.2, there is some existitng solution such TBS scaling to improve the performance, So the impact due to 1Rx is not significant. In this regard, considering the gains in real business and the pains, we think the it would be desirable to support 1Rx. Furthermore, as commented by oppo, concern, either acess control or coverage recovery could be considered. On the other hand, as the observation in RP-202746, compared with 1Rx in the form factor limited wearables, 2Rx can not brings the gain expected due to less antenna isolation and efficiency, so reduced the Rx to 1 is reasonable for the FR1 bands that currently requires 4 Rx branches.To move forward, we can accept the proposal by CMCC as a compromised soluiton. |
| ORANGE | Orange does not agree with allowing 1 Rx for bands where 4 Rx is mandated today (both in TDD and FDD). Reduction of number of antennas has a huge impact on network capacity. . Orange did submit a RAN1 contribution to illustrate such impact (R1-2004270).We feel reduction the mandatory requirement of 4 Rx down to 2 Rx is already a compromise. |
| Panasonic | We support the view from Sierra Wireless. |
| Telecom Italia | We think the operators’ concerns have not been addressed in this discussion. To Samsung: a 20% loss in network capacity IS NOT A NEGLIGIBLE LOSS!!!The issue is the fact that underperforming devices, if used for data intensive applications, are jeopardizing the network resources. Therefore we require:* To insert in the scope since the beginning a procedure to identify devices with redcap capabilities. Note that this solution may not be sufficient to bar access to these devices, due for example to net neutrality regulations
* To limit (for both FDD and TDD) the resources these devices can use. Therefore we propose to limit the number of PRBs that can be assigned to these devices, the maximum channelization (e.g., for n78 the maximum number of PRB could be fixed to those available with a 20 MHz channelization). Also these devices should not support Carrier Aggregation
 |
| Vodafone | We should go with 2Rx for “current 4Rx” bands in Rel-17 (as Ericsson said this is not just TDD).Devices would anyway need to support lower frequency bands to be able to operate widely, so could support 1Rx for current 2Rx FDD bands. Clearly channel bandwidth is not such an issue so that seems to match quite well with operation in those bands. We also think that the reduced Rx antennas capability should be coupled with the 20MHz channel bandwidth support only.Regarding the higher antenna efficiency with 1Rx compromise proposal, it is unclear to us how that can be realized in practice as we have no baseline reference OTA requirement in place. So while on paper it might look like a compromise, in practice we don’t see how it could be enforced.Regarding mechanisms to allow networks to deny operation to specific UEs if the operator does not like their capability, when these devices may be sold on the open market we do not believe that this is a workable as a generic solution, as it would just lead to customer complaints and force operators to allow those devices on their networks. Therefore we prefer 3GPP to not open the floodgates in the first place. |
| Nokia, Nokia Shanghai Bell | While we would prefer keeping with minimum of 2 rx with FR1 TDD bands, we do have understanding on the challenges with wearables for such a case. One possibility would be to consider defining tighter OTA performance requirements in RAN4 for such a single antenna UE and after those are achieved to add support for such a UE in RAN1/RAN2 side. This means that the corresponding objectives of defining OTA requirements need to be added to the WID. Note the support of 1 RX with FR1 TDD bands would also require additional work for downlink coverage recovery. |
| Qualcomm | In the end, this discussion will be about whether wearables should be adopted as a 3GPP technology or whether they should be outside of the 3GPP requirements. Agreeing on some requirements that historically have no relevance to wearables will not do much in terms of providing 3GPP support.Somewhat confused regarding what some companies mean by compromise in this discussion. This is not an exercise of choosing some number in the middle.What we should understand is whether when we put two antennas 2.5cm apart in a wearable what kind of antenna correlation we should expect and what would be the corresponding gain. When some companies say there is a huge impact on network capacity, what do those companies assume for antenna correlation for the 2Rx case. Uncorrelated? It is a bit unclear why it should be expected that NR wearables would have different number of antennas in the end compared to LTE wearables. This is determined by size, not cost. Why would NR wearables expected to be bigger. |
| China Unicom | 2Rx is still the preferred option for RedCap UEs. We are generally fine with 1Rx on the premise that there is no antenna efficiency loss of 3dB. It is not clear how to guarantee a gain of 3dB so that 1Rx and 2Rx can achieve comparable coverage.  |
| Huawei, HiSilicon | We do think it is important for 3GPP not to permanently discard the cost saving from reducing the Rx branches as far as possible. The coverage gap in going from 2 Rx to 1 Rx (for FR1 TDD) is on average ~3 dB, so it seems that whether/how to handle this needs to be settled in a way forward. The suggestion by CMCC is one possibility, which appears to imply saying there are no different RAN4 requirements for 1 Rx UE than 2 Rx UE. This has no impact on RAN1 specs, so may be an attractive way forward.In addition, cell access restriction for RedCap UEs will be introduced, and the WID could be written to indicate that it applies to a UE with reduced number of Rx branches.If the CMCC way forward is agreed, then there is not a need for early identification of 1 Rx branch UEs.See section 2.4 for a concrete wording suggestion (though others also certainly exist). |
| BT | Like many other operators, we are concerned about the impact on our network of permitting a reduction in antennas. With other restrictions we could accept 2Rx, but NOT 1Rx. If such RedCap devices are to be permitted, then they should be limited accordingly, and we believe that there should be constraint on the channel bandwidth and/or the number of PRBs.We also propose that RedCap devices should not be permitted to implement CA or DC. |
| SONY | The form factor limitation of some wearable devices means that realistically there is not a significant performance difference between 1RX and 2RX.Our understanding is that this could be reflected in there being a lower antenna efficiency for 2RX compared to 1RX. We are not sure how a “higher antenna efficiency assumption for 1 Rx” would impact the specifications, so we think that it would be safer to consider a “lower antenna efficiency assumption for 2RX” as that better reflects the situation. |

## 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. |
| Apple  | We are supportive for this, especially considering the fact that latency requirement for target Redcap use cases are already relaxed, the 7% cost reduction benefit and power saving gain. On the other hand, it is ok for us to put it with 2nd priority list if there is TU limitation. |
| CATT | We do not support relaxed UE processing time in terms of N1/N2. As emphasized in TR, this feature brings marginal cost reduction (~2%, the minimum one amond all features, averaged result from all companies), but largely increase the gNB scheduling complexity. Such feature requires heavy gNB re-development, and hampers the deployment of RedCap UE in return. |
| Samsung | The complexity reduction from relaxed UE processing times is not that attractive. If we want to support Relaxed UE processing times, we’d like to suggest to discuss more details, e.g., only relaxed processing time relaxed or both relaxed and nomal processing times are supported for Redcap UE, and the assumption of initial access.  |
| DISH Network | We are ok if relaxed N1/N2 processing times are defined for RedCap, however we think this should be discussed together with Early identification as at least we think network should be made aware of such UE as early as possible to avoif problems e.g in initial access. |
| Ericsson | We do not think this feature can be justified considering the small complexity reduction benefit and impact on the scheduler implementation. There are already many features that have more promising complexity reduction benefits to be worked on, and we should focus on those features. In the webninar, it was mentioned that the DL maximum modulation relaxation has similar benefit as relaxed UE processing times, and so if that is included relaxed UE processing times can also be included. We would like to point out that DL maximum modulation relaxation has no coexistece impact and no impact on the scheduler implementation. It is much easier to implement DL maximum modulation relaxation, compared to relaxed UE processing times. |
| ZTE | Considering the low cost saving gain, the increase of the complexity for the scheduling, the potential coexistence issues with legacy UEs during initial access, we propose “Relaxed processing time features is not considered for RedCap UEs in Rel-17”. |
| Xiaomi  | We think this is not high priority feature in the current stage, maybe it could be considere in the future release. |
| ORANGE | No strong views on the matter. |
| Panasonic | From TU availability perspective and the gain perspective, not to include it or lower priority. |
| Telecom Italia | This is automatic if the available resources (# of PRBs, max channelization) are fixed |
| Vodafone | Every small feature like this is one more thing that the network needs to be compatible with, and hence one more risk that there are devices that are incompatible with networks.  |
| Nokia. Nokia Shanghai Bell | We don’t see major benefit from this, some 2% cost saving was only observed from this. Considering the need to limit overall number of objectives we prefer not to incude relaxed processing times in the objectives of the WID |
| Qualcomm | In our view, relaxed processing time can be adopted as an option, as long as RedCap UEs with Rel-15/16 ptrocessing times are also supported.  |
| China Unicom | We are not in favor of doubling the N1/N2, because this will grantly increase the complexity of the scheduling in the network side.  |
| MediaTek | The complexity reduction by relaxing the UE processing timeline is marginal (<2%). The benefits expected from such a relaxation would not be in proportion to the standardization effort, the impact on NR L1 procedures, the impact on scheduling and the potential limitation on scope of applicability.Hence, relaxed UE processing timeline (N1/N2) should not be supported for RedCap UEs. |
| Huawei, HiSilicon | This is worthwhile. The TR is in our view rather pessimistic about the complexity reduction benefit due to being averaged out, whereas implementations can achieve somewhat more than the average.Like others, we assume the WID would write this as “2x processing time capability 1”, to be concrete. We also emphasise that the range of cost reductions seen in RAN1 was pretty wide, and is somewhat hidden by only looking at the average – but even the average is similar to HD-FDD type A, and DL modulation restriction.Whether an operator wants to support it can be indicated in the signaling related to cell (re-)selection, which results in barring UEs that need it. Note that RAN2 have already agreed to introduce system information that will indicate if RedCap UEs can camp on a cell. The WID could say that this will be included in the cell access restriction signaling, so that the point is beyond debate.For the network that allows relaxed processing time, early identification can be used to find those UEs, and similarly the WID could indicate this will be done, to make the WG task clearer.See section 2.4 for a concrete wording suggestion (though others also certainly exist). |
| SONY | This feature does not bring significant complexity gain. Our preference is to not include this in the WI scope. This would help to minimize the number of objectives in the WID. |
| Frauhofer | Although providing rather small gains, the relaxed processing time is worth to be included at least as a second priority target. |

## 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.  |
| Apple  | Power saving schemes studied under Redcap study items are mainly driven by some specific considerations for Redcap devices, e.g. extremely longe battery life, relaxed latency requirement, low mobility for sensors and video survilense. Regarding the solutions, at least reducing the maximum number of BDs (Scheme #1) should be standardized in Redcap WI as it is mainly justified by the characteristic of Redcap devices listed above.  |
| CATT | In our view, Scheme#1 can be included in RedCap WI since it does not only bring power saving gains but also reduces the UE complexity. Note that there are 2 alternatives under Scheme#1, due to the divergence whether the DCI size budget can be additionally reduced or not. At least the BD number and DCI size budget should be specified, if Scheme#1 is included.Other schemes can be handled under power saving WID. |
| Samsung | For the WID, we think it should at least specify “*PDCCH monitoring reduction scheme(s) to abtain smaller BD limit, i.e. maximum PDCCH candidates per slot/span*”. Because, we think scheme(s) to abtain smaller BD limit is RedCap specific feature with no overlapping to R17 PS WI. For R17 PS, it focus on dynamic adaptation on PDCCH monitoring behavior by down-selecting from SS set group switching and PDCCH skipping. The PS in R16/R17 can be applicable to both legacy UEs and RedCap UEs. However, the reduced PDCCH monitoring studied for RedCap focus on reduced BD limit. And the reduced maximum PDCCH candidates per slot/pan is determined by UE capability, which is applicable to RedCap UEs only. In addition, it’s also OK to further specify “with target for minimized increment PDCCH blocking rate”, if network scheduling or PDCCH blocking impact is a concern for comapines, such that*“Specify PDCCH monitoring reduction scheme(s) to abtain smaller BD limit, i.e. maximum PDCCH candidates per slot/span”, with target for minimized increment PDCCH blocking rate.”*In general, we think PDCCH blocking is not an issue for supporting BD reduction in Redccap due to the following reasons* a) PDCCH blocking is caused mainly by increased number of UEs scheduled simultensouly rather than maximum number of PDCCH candidates.
* b) It may or may not be impacted by BD reduction depending on multiple factors at least including BW, Subcarrier Spacing (SCS), CORESET size, AL distribution.
* c) the impact becomes small or negligible if we consider latency-insensitive feature of RedCap use cases. However, the PDCCH blocking rate evaluation results captured in the TR didn’t really consider latency torelation.
 |
| Ericsson | In our view, the benefit is too small even with an overly idealized traffic model (i.e. DL only traffic). Note that according to the SID, RedCap use cases, such as industrial wireless sensors and video survalliance cameras are expected to have UL heavy traffic. Furthermore, we believe a similar benefit can be achieved by properly configuring the UE using existing Rel-15/16 mechenism. Some proponents seem to be interested in reduced PDCCH monitoring for UE complexiy reduction so they are not completely satisfied if the UE power saving benefit can be achieved by UE PDCCH monitoring configuration. However, it is worth pointing out that reduced PDCCH monitoring is not a candidate scheme for UE complexity reduction. Its benefit in UE complexity reduction has not been analyzed in the SI.RAN2 is studying additional UE power saving features, and we expect the RAN2 features will provide more significant benefits. So we think at least we should wait for the completion of the RAN2 study to decide which power saving features need to be prioritized in the RedCap WI. |
| ZTE | The antenna reduction, bandwidth reduction and the limited use cases for RedCap cause that the DCI format for RedCap UE needs to be reconsidered, which may have an impact on the reduced blind decodings or DCI sizes budget. It is a RedCap-specific issue and does not belong to the power saving WI.Additionally, current mechanism can not configure the maximum BDs limit. The change of the current maximum BDs limit and DCI size budget are required for the RedCap UEs. More specifically, reduced maximum number of blind decodings per slot with reduced DCI size budget and/or reduced maximum BDs limit, targeting negligible increase in PDCCH blocking rate, can be considered in the RedCap WID. |
| Xiaomi | In our opion, only Redcap-specific solution is considered here. Solutions common for Redcap and other NR UE should be discussed in power saving project. In addition, any schemes should target little impact on the blocking probability and scheduling flexibility. |
| ORANGE | Issue to be addressed in the Power Saving WI. Reducing the number of blind decodes may have a detrimental impact on network by reducing its scheduling flexibility, and this impact needs to be properly assessed. |
| Panasonic | The number of BD reduction of the configuration is possible since Rel.15/16. To reduce the maximum number of supported BDs itself would not be required to be supported as the complexity reduction gain is not so obvious. |
| Telecom Italia | Same view as Orange |
| Vodafone | We are not convinced that the overall benefit to battery “lifetime” in the device is so significant. Also this can be configured from network side already today, so we think that scheduler freedom needs to be maintained as what is best may also be driven by the device traffic profile. Considering the above, and considering that this is not a complexity reduction feature for the device, it is unclear to us why we need to specify this as a capability of the device if the feature already exists and is able to be configured by networks.  |
| Nokia, Nokia Shanghai Bell | Power saving enhancements should be covered in the power saving WID, preferable as a general solution like agreed already earlier. There exists already UE power saving solutions in Release 15, Release 16 and further enhancements developed in Release 17.Network can already configure necessary configuration for reduced capability UE. We do not see need for further work on reduced PDCCH monitoring especially as it will complicate network operations and complexity.  |
| Qualcomm | We support BD limit reduction according to Scheme#1. This will provide both complexity and power reduction benefits. |
| MediaTek | The equivalent power saving due to BD reduction (i.e. Scheme #1) can already be achieved using existing R15/16 configurations (e.g., configurations for number of PDCCH candidates and number of DCI sizes to monitor). Hence, compared to using existing R15/16 functionalities, there is **no power saving** achieved by adopting smaller numbers of BDs for RedCap UEs. On the other hand, it can be seen from the observations captured in the TR that BD reduction increases the PDCCH blocking probability significantly in many cases.Hence, PDCCH monitoring reduction should not be supported for RedCap UE. |
| Huawei, HiSilicon | The possibility to have no increase in PDCCH blocking rate whilst reducing the number of BDs per slot arises from the reduced DCI field sizes which are expected to be possible for RedCap UEs, due to their reduced span of support. Thus if there is an objective in RedCap for this, it should be as per Alt 1a from RAN1 (“*Reduced maximum number of BDs per slot with additionally reduced DCI size budget - 0% PDCCH blocking rate increment*”).  |
| SONY | The study item showed negligible power saving gain from reduced PDCCH monitoring, so we think that reduced PDCCH monitoring does not need be included in the WID. |
| Fraunhofer | We think that this should be treated in the RedCap WI since it allows a complexity reduction on top of the power saving gain. |

## 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.  |
| Apple | We also prefer deferring the refinement of RAN2-led objectives in WID to RAN #91-e until RAN2 studies complete  |
| CATT | We would like to apply the same principle for the convertion of the SIs so we prefer to include RAN2-led items in RAN #91-e. |
| Samsung | Based on RAN 1 observations, it is benificial to support early identification of Redcap UEs. If UE cagetories is a concern, we can consider something as “Specify early UE capability report in RACH procedure, e.g., PRACH, Msg 3. “ |
| Ericsson | We suggest the WI to specify both early UE identification in Msg1 and Msg3. The pros and cons of Msg1 and Msg3 based early identification have been captured in the TR 38.875. The pros and cons may depend on the specific deployment scenario. It can be up to the network to configure Msg1 or Msg3 for early identification adapting to a specific deployment scenario. |
| ZTE | To avoid the impact during initial access, the RedCap UE should be identified as early as possible. If the RedCap UE is identified, a minimum set of L1 capabilities is assumed during initial access. |
| Xiaomi | Since the study is onging in RAN2, we can not exclude supporting of early indication by Msg1/3 at least for now. In addtion, we would like to share CMCC’s view that early indication should not be a mandaroty requirement. For example, for the NW with very good coverage, coverage recovery is not needed even for Redcap UE with 1Rx. In this case, early indication is not needed. |
| ORANGE | Orange supports the principle of having early identification of UEs. More generally, it is important to capture the objective of specifying “network control of redcap UEs”, with UE identification allowing possible network access retrictions.Although RAN2 work is not complete, these high level objectives should be captured within the WID to be approved at this plenary, with the understanding that revisions will be made in March after RAN2 work completion. |
| Panasonic | Early identification of RedCap UEs by Msg1 is useful in some case like wider system band but increasing PRACH overhead in narrow system band is not desirable. We see it would be useful for the network to select to use early identification or not to use early identification using Msg1. We don't see the specific need to modify WI objective. |
| Telecom Italia | Same view as Orange. This may not even be sufficient to bar devices from networks due to regulations, but it is the bare minimum to start the work. |
| Vodafone | No specific proposal but we need to ensure that there is compatibility between networks and devices. |
| Nokia, Nokia shanghai Bell | It will be important to ensure UE capabilities are defined in such a way that RedCap capabilities/relaxations shall not be available for a regular smartphone, with details left for RAN2 to handle. Overall we support the objective as “Specify functionality that will allow RedCap UEs to be explicitly identifiable to networks and network operators and allow operators to restrict their access” |
| Qualcomm | Early identification of RedCap UEs would be needed, so it is better to add an explicit objective. For which types, if not all RedCap UEs this technique would apply to can be discussed in the WGs.  |
| China Unicom | We support for early identification of RedCap UEs and possible network access retrictions. |
| MediaTek | RAN2 are currently discussing the need for early identification as well as potential solutions. From a procedural perspective, this is a RAN2-led objective and therefore its inclusion in the WID should be discussed only once RAN2 has completed its study. To address operator’s concerns raised online, the current objective in the draft WID [18] should be sufficient at this point, i.e. “*Specify functionality that will allow RedCap UEs to be explicitly identifiable to networks and network operators and allow operators to restrict their access*.”. |
| Huawei, HiSilicon | Given that is strongly necessary, it should be more clearly reflected in the WID, whereas at the moment we have two rather generic bullet points under the RAN2 objectives.If the outline RAN2 objectives are kept in the WID, we suggest referring to either “early identification” which is to be understood from the TR, or to a message of the random access procedure, such as is done in section 11.1 of the TR.In addition to the point on early identification, these bullets of the WID also mention cell access restriction. If we follow the way forward suggested in section 2.1 and 2.2, then cell access restriction includes 1 Rx UEs and doubled processing time UEs. Early identification is not needed for 1 Rx UEs, but includes double processing time UEs. It may be sufficient to have this understanding/expectation in RAN rather than write it in the WID, so the WGs can decide finally how to design it. But suitable wording would also be OK with us, if needed.Question to the rapporteur – is there a difference in WID terms if we simplify the language to say “identifiable to the network…”? Otherwise, the wording might be calling for two different solutions to one problem (one for “networks” and one for “network operators”). |
| BT | We believe that early identification of such devices is important, to enable the network to be able to accommodate them appropriately.  |

## 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.

|  |  |
| --- | --- |
| **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.
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| Spreadtrum  | Agree with moderator’s proposal: HD-FDD type A is supportedFor 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.
 |
| Apple  | We support to define HD-FDD Type A for Redcap devices. As pointed out by OPPO, for RRC\_CONNECTED mode UEs, support of BW larger than 20MHz or larger number of MIMO layers to achieve the demanding peak data rate 150Mbps can be further discussed in work item phase as part of Redcap UE capabilities.  |
| CATT | We are fine to support HD-FDD type A if the scope can be clearly defined. In our view, only UE capability report and UL-DL/DL-UL switching times need to be defined. In addition, we would like to make it clear that HD-FDD type A is an optional UE feature. |
| Samsung | We support Type A HD-FDD, which can be an optional feature for Redcap device.The support of larger BW after initial access can be further discussed in WG level. We don’t expect much specificiation impact to support it, however on the other hand, it provides possibility to support higher bit rate with limited complexity impact.  |
| DISH Network | We support to define HD-FDD Type A for RedCap. The UE cost benefits are best realized when a device supports multiple bands with limited RF FE content.  |
| Ericsson | If HD-FDD type A is supported by the specification, FD-FDD should also be supported by the specification.In the Monday’s webinar, one company mentioned that DL coverage enhancement is needed in FR2. According to the SI findings, DL coverage enhancement is not neded in FR2 if the UE with 12 dBm TRP is considered, but is needed if UEs with 23 dBm TRP is considered. We believe most of the FR2 UEs are limited to max TRP of 12dBm, although there are also UEs with 23 dBm TRP. But considering there are 12 dBm UEs in the network, cell planning (from coverage perspective) needs to be based on 12 dBm UEs. (otherwise 12 dBm UEs will have UL coverage issue) Once the cell planning is based on 12 dBm, DL coverage is not a problem for 23 dBm UEs. Thus, our view is that coverage compensation is not needed in FR2.For FR1, we are fine to defer the work on coverage recovery aspects until after RAN#91e in order to be able to assess the reusability of the work done in the Coverage Enhancement WI.For bandwidths and other aspects, the current draft WID in [18] is preferred. |
| ZTE  | H-FDD type A is low priority. Not be considered if TU is limited.Regarding “Specify support for the following UE complexity reduction features [RAN1, RAN4]”, this objective may have RAN2 specification impact.For bandwidth reduction in FR1, maximum UE bandwidth larger than 20MHz can be considered as an optional capability after initial access.For coverage recovery, there was comment in the first GTW session that PUSCH enhancements can be handled in CE WI but Msg3 or DL channel coverage recovery can be considered in RedCap WI.  In our views, it is not reasonable to consider PUSCH and Msg3 enhancements separately in the two WIs.  As discussed in CE SI, some regular PUSCH enhancements can be applied to Msg3 PUSCH but repetition has to be enabled for Msg3 first before these enhancements can be applied to Msg3. Therefore, it would be more reasonable to introduce PUSCH and Msg3 enhancements together in the CE WI.   Depending on the conclusion of the number of UE Rx branches, coverage recovery may be needed for several DL channels. The potential enhancements for DL channels for RedCap UEs if identified could be also be included in CE WI (given that broadcast PDCCH is also identified as a bottleneck channel in CE SI). Therefore, we suggest to remove the entire objective of coverage recovery from the RedCap WID. Although we don't forsee any need at this point, we can further discuss in the future RAN plenary whether further coverage recovery is needed after sufficient RAN1 discussion on coverage enhancement techniques in the CE WI.  However, we don't see the need of explicitly capturing this checkpoint in the RedCap WID at this point. |
| Xiaomi  | We think Both HD-FDD type A and FD-FDD are supported for FR1 FDD RedCap UEFor bandwidth description, we agree with OPPO to adopt the RAN1 conclution to further discuss it in the WI phase. |
| ORANGE | Low priority objective. |
| Vodafone | We see some benefits in HD-FDD Type A especially for n3, n8, n20 in terms of UE complexity reduction and providing some “edge of coverage” benefit in DL performance (improved Rx sensitivity). However, similarly to the N1/N2 processing time comment, we also worry a bit that the more RedCap specific L1/L2 protocol changes that we need to cope with on the network side, the higher probability that we have some devices which are not compatible with networks globally and in roaming scenarios, which may lead to FD-FDD being relied upon anyway. Regarding wider bandwidth after initial access, we do not support this as it does not seem to fit with the whole aim of the work. |
| Nokia, Nokia Shanghai Bell | We agree that HD-FDD type A should be supported |
| Qualcomm | Irrespective of the choice of the number of antennas, specifying DL coverage recovery mechanism needs to be added in the objectives. On the other hand, UL coverage enhancements can be considered in the CovEnh WI. Additionally, we support HD-FDD for the following reasons: 1. Reduced insertion loss provides DL coverage recovery
2. Power savings achieved by higher UL efficiency due to smaller insertion loss
 |
| MediaTek | We agree on supporting HD-FDD Type A for Redcap UEs.On coverage recovery, it is essential to avoid any duplication of work in multiple WIs. As already highlighted by several companies, there is no coverage issue identified for RedCap UEs in FR2. In FR1, the coverage gap identified in the RedCap SI was mainly for PUSCH. Given that the CE WI will introduce coverage enhancements for (at least) PUSCH, we don’t see a need to include coverage recovery mechanisms in the RedCap WI. |
| Huawei, HiSilicon | The objective **on reduction of MIMO layers** needs to be clarified:* + Reduced maximum number of DL MIMO layers:
		- For a RedCap UE with 1 Rx branch, the supported number of DL MIMO layers is 1.
		- For a RedCap UE with 2 Rx branches, the supported number of DL MIMO layers is 2.

**On HD-FDD type A**, if it is supported on the justification of a worthwhile cost reduction, then the same motivation exists for relaxed processing time, which gives at least as much (and, in our view, rather more) complexity reduction, and is applicable to TDD as well as FDD bands. |
| SONY | Agree that HD-FDD type A is supported.Any coverage enhancement for the UL can be considered in the Rel-17 coverage enhancements WI.The 3dB UL coverage enhancement for Redcap is due to the assumption of a 3dB lower antenna efficiency. This was an input assumption to the SI. The SI then considered a set of techniques that impacted the DL (especially reduced number of antennas). Due to the evaluation assumptions used, especially the antenna efficiency and UL data rate assumptions, despite there being no redcap techniques that affected the UL, it was concluded that UL coverage needed to be enhanced. This is not especially logical.In the SI, we considered redcap techniques that impacted DL performance. The performance loss was considered in terms of coverage, but could equally have been considered in terms of spectral efficiency (the performance loss could have been considered in terms of a lower data rate, rather than a lower coverage). Our preference would be that the WI considered techniques to mitigate the DL spectral efficiency loss from redcap, rather than the coverage loss. However, this was not really considered in the SI. |

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# References

1. RP 202180 Scoping for R17 RedCap WI Futurewei
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
8. RP 202525 Views on RedCap WID scope NTT DOCOMO, INC.
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