**3GPP TSG RAN WG1 #107-e R1-211xxxx**

**e-Meeting, November 11th – 19th, 2021**

**Agenda item:** 8.16.6

**Source:** Moderator (NTT DOCOMO, INC.)

**Title:** [draft] Summary on UE features for REDCAP

**Document for:** Discussion and Decision

# **Introduction**

This document summarizes contributions submitted to AI 8.16.6 regarding UE features for RedCap and captures the following email discussion.

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| [107-e-R17-UE-features-REDCAP-01] Email discussion UE features for REDCAP – Shinya (DOCOMO) * 1st check point: November 15
* Final check point: November 19
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In the updated RAN1 UE features list for Rel-17 NR after RAN1 #106bis-e [1], there are following feature groups for RedCap.

* 28-1 RedCap UE
* 28-2 Number of UE Rx branches and DL MIMO layers for RedCap UE
* 28-3 Half-duplex FDD operation type A for RedCap UE
* 28-5 UL 256QAM support for RedCap UE

The issues to be discussed are tagged and colour coded with High priority, Medium priority, or Low priority, considering RAN2 impact especially for capability signaling design.

In this round of the discussion, companies are requested to provide comments on the proposals and questions tagged FL2.

# **28-1: RedCap UE**

In [1], FG 28-1 is captured as below.

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| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (Sidelink WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
|  28. NR\_redcap | 28-1 | RedCap UE | 1. Maximum FR1 RedCap UE bandwidth is 20 MHz.2. Maximum FR2 RedCap UE bandwidth is 100 MHz.FFS whether to add any other basic features for RedCap UE |  | Yes |  | Network assumes the UE is not a RedCap UE | Per UE | No | No |  | RedCap UEs do not support carrier aggregation or dual connectivity. | Optional with capability signalingRedCap UE must indicate this FG is supported |

Following feedbacks are provided in contributions for the RAN1#107-e meeting.

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| [2] | Ericsson | FG 28-1 (‘RedCap UE’) is only defined by the reduced maximum UE bandwidth. We would be fine with adding more basic features in the definition if needed. The need seems to depend on whether other FGs are additive or subtractive relative to FG 28-1. Traditionally, FGs are additive, meaning that they add functionality rather than remove functionality. If we want to go this way, FG 28-1 should be defined so that it corresponds to the simplest Rel-17 RedCap UE. In that case, FG 28-1 should have additional components corresponding to single Rx branch, single DL MIMO layer, HD-FDD operation (in case of FDD bands), and no DL 256QAM support (in case of FR1), and then separate capability indications would be needed for RedCap UEs that happen to support one or more of two Rx branches, two DL MIMO layers, FD-FDD operation (in case of FDD bands), and DL 256QAM support (in case of FR1).1. For FG 28-1 (‘RedCap UE’), add components so that FG 28-1 corresponds to the simplest Rel-17 RedCap UE, i.e., single Rx branch, single DL MIMO layer, HD-FDD operation (in FDD bands), and no DL 256QAM support (in FR1). Note that in that case, the other RedCap FGs should be defined so that they add functionality (two Rx branches, two DL MIMO layers, FD-FDD operation, DL 256QAM) on top of FG 28-1.

Note that the above proposal may have impact on all RedCap FGs.For FG 28-1 (‘RedCap UE’), FR1/FR2 differentiation would be needed if it is desired to indicate that a UE supporting both FR1 and FR2 is a RedCap UE in one of the frequency ranges but not in the other frequency range. It is currently not clear to us whether there might be a need for such a hybrid UE.1. For FG 28-1 (‘RedCap UE’), discuss whether there is any need of FR1/FR2 differentiation.
2. For FG 28-1 (‘RedCap UE’), for the fields “Consequences if not supported”, “Type”, “Need of FDD/TDD differentiation” and “Note”, the highlighted text can be used as is.
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| [3] | Huawei, HiSilicon | FG 28-1: no other features needs to be added as discussed in [5]. And we think no need of FDD/TDD or FR1/FR2 differentiation, because UE type does not related to band or duplex mode. Also, channel bandwidth report in R15/16 does not have band or duplex mode differentiation, so does for RedCap UEs. FG 28-2: for non-RedCap UEs, *maxNumberMIMO-LayersPDSCH* is reported per *FeatureSetDownlinkPerCC*, which is reported per CC based on per band per BC. As RedCap UEs do not support CA, number of UE Rx branches and DL MIMO layers is reported per band is sufficient and reasonable. FG 28-3: it was discussed in SI stage that a HD-FDD UE can benefit from lower cost with removal of duplexer, which results in a hardware implementation of the UE without duplexer in any band. Thus, this can be per UE reported.***Proposal 2:*** *FG 28-1 and FG 28-3 to be reported per UE without xDD/FRx differentiation and FG 28-2 to be reported per band.* |
| [4] | FUTUREWEI | We have four observations with the revised formulation.***Observation 1.***1. ***FG 28-1 must include a basic feature for a reduced number of Rx branches***
2. ***FG 28-2 must be removed as indicated by RAN2***
3. ***FG 28-5 must be removed since UL 256QAM is not in the WID***
4. ***Capture Early Indication functionality***

Basic featureFor RedCap, the current formulation in [3] is dangerous as it allows RedCap UEs to support Reduced Bandwidth 28-1 but NOT a reduced number of RX branches. As we stated in [1], FG 28-1 should simply indicate that a RedCap UE is not 4RX and refer how the existing signaling is used to determine the number of RX branches. Note this statement is also consistent with the FL comment in [2] (yellow highlighting added)* + *The WID [1] indicates that the following capabilities are not applicable for RedCap UEs:*
* *Carrier aggregation*
* *Dual connectivity*
* *UE bandwidths wider than 20 MHz in FR1 or wider than 100 MHz in FR2*
* *More than 2 UE Rx branches or more than 2 DL MIMO layers*

Some ways capture that a RedCap UE does not have 4RX branches are * Add the statement “no more than 2RX branches” to the cell that says CA and DC are not supported
* Add the statement “no more than 2RX branches” to the components cell
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| [5] | vivo, Guangdong Genius | **Issue#1 FFS whether to add any other basic features for RedCap UE**For issue#1, extensive discussions were made in the last meeting. Some companies proposed to FG 28-2 of “Number of UE Rx branches and DL MIMO layers” and FG 28-3 of Half-duplex FDD operation type A into the FG 28-1. It is noted that the same discussion was held in the RAN1#106-e meeting on whether to include the number of RX branches, duplex mode, maximum modulation order and no support of CA/DC into the RedCap UE type [2]. However, no decision can be made. As observed by many companies that during the initial access, only the capability that network can assume without ambiguity is maximum UE bandwidth. Other capabilities like FG 28-2, FG 28-3, FG 28-5 can be signalled by UE capability report. Therefore, it is not necessarily to merge FGs 28-2/28-3 into the FG 28-1. **Proposal 1: There is no need to merge FGs 28-2/28-3 into the FG 28-1.**In addition to the maximum UE bandwidth, since FG 28-1 is used to capture the basic RedCap UE features, we think following functions should be discussed further on whether and how to include them as the RedCap UE basic UE features. * + Adding basic FG for the operation with SSB in a UE-specific BWP for RedCap UEs

Based on the discussion in RAN1#106bis-e meeting, Option 2 was considered as one compromised solution for RedCap UE operation on the initial/non-initial DL BWP [3]. The majority shared the views that if an RRC-configured DL BWP (if it does not include CD-SSB and the entire CORESET#0) is configured in FR1, then the RedCap UE shall expect it to contain NCD-SSB for serving cell but not CORESET#0/SIB. Therefore, we think following should be added in the FG 28-1 as basic RedCap UE features.3. Basic BWP operation for RedCap UE* + - 1 UE-specific RRC configured DL BWP per carrier
		- 1 UE-specific RRC configured UL BWP per carrier
		- RRC reconfiguration of any parameters related to BWP
		- **BW of a UE-specific RRC configured BWP includes BW of SSB for PCell/PSCell**
		- **BW of UE-specific RRC configured BWP may not include BW of MIB-configured CORESET#0**

**Proposal 2: Following “Basic BWP operation for RedCap UE” should be added as RedCap UE basic UE features and can be considered to be included in the component column of the FG28-1.****3. Basic BWP operation with restriction for RedCap UE*** + - **1 UE-specific RRC configured DL BWP per carrier**
		- **1 UE-specific RRC configured UL BWP per carrier**
		- **RRC reconfiguration of any parameters related to BWP**
		- **BW of a UE-specific RRC configured BWP includes SSB for PCell/PSCell**
		- **BW of UE-specific RRC configured BWP may not include BW of MIB-configured CORESET#0**

For a RedCap UE operation without SSB in a UE-specific BWP, similar as FG6-1a for non-RedCap UEs, this should be specified as optional FG. A RedCap UE can optionally supports the FG6-1a with capability signaling. FG28-x gives one example.

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| 28. NR\_redcap | 28-x | BWP operation without restriction on BW of BWP(s) for RedCap UE | BW of UE-specific RRC configured BWP may not include BW of the SSB for PCell/PSCell |  | Yes |  | Impact on UE complexity | [Per band] | No | [No] |  | RedCap UEs do not support carrier aggregation or dual connectivity. | Optional with capability signaling |

**Proposal 3: An optional, new FG can be introduced for the operation without SSB in a UE-specific BWP for RedCap UEs** * + Separate initial UL/DL BWP for RedCap UE

Following agreements and working assumptions related to the separate initial UL/DL BWP for RedCap UE were made in RAN1#106bis-e meetings [1].

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| Agreement: * For a cell that allows a RedCap UE to access, network can configure a separate initial UL BWP for RedCap UEs in SIB
	+ It can be used both during and after initial access.
	+ It is no wider than the maximum RedCap UE bandwidth.
	+ It is always configured if the initial UL BWP for non-RedCap UEs is wider than the maximum RedCap UE bandwidth
	+ This applies to both TDD and FDD (including FD FDD and HD FDD) cases

Working Assumption: * For a cell that allows a RedCap UE to access, network can configure a separate initial DL BWP for RedCap UEs in SIB.
	+ Working assumption: It can be used during initial access
	+ It can be used after initial access.
	+ It is no wider than the maximum RedCap UE bandwidth.
	+ FFS: It is always configured if the initial DL BWP for non-RedCap UEs is wider than the maximum RedCap UE bandwidth.
	+ This applies to both TDD and FDD (including FD FDD and HD FDD) cases.
	+ Working assumption: It applies at least after initial access for FR1 when MIB configured CORESET#0 is included
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Depending on network’s deployment strategy, there could be use cases that only separate initial UL BWP is configured for the RedCap UEs for at least offloading the UL transmissions related to initial access. Therefore, the new FGs related to the separate initial DL BWP and the separate initial UL BWP should be introduced for RedCap UEs. For a separate initial UL BWP, it should include the configuration(s) needed for RedCap UE to perform random access, e.g., the RedCap-specific PRACH configuration, Msg.3 and PUCCH for Msg.4 acknowledgment etc. For a separate initial DL BWP if configured, further discussion is needed on what should be included within the separate initial DL BWP. As discussed in our companion contribution [4], the separate initial DL BWP should at least include the CSS/CORESET for random access, and it is configurable to include the SSB, CORESET/CSS for paging, CORESET/CSS for SIB1/SIs and MIB-configured CORESET#0.Besides, according to the agreements and working assumptions, a separate initial UL and DL BWP can be used during the initial access before UE indicating its capability, further discussion is needed on whether the two FGs should be optional without capability or optional with capability. **Proposal 4: Introduce following new FGs related to the separate initial UL BWP and the separate initial DL BWP for RedCap UEs:** * **FG 28-y: A separate initial UL BWP**
	+ **It includes the configuration(s) needed for RedCap UE to perform random access;**
* **FG 28-z: A separate initial DL BWP**
	+ **It includes CSS/CORESET for random access.**
	+ **It may include CSS/CORESET for paging and in such case, the RedCap UE expects it to contain NCD-SSB for serving cell but not CORESET#0/SIB.**

**Proposal 5: For the two new FGs of the separate initial UL and DL BWP, further discussion is needed on whether the two FGs are optional without capability signaling or optional with capability signaling.** **Issue#2: The type for FG 28-1**For issue#2 of the indication type for FG 28-1, it can be found in TS 38.101 Table 5.3.5-1 that many bands could be deployed with channel bandwidth of up to 20MHz, for example band n2/n5/n8, …. In these bands, since the channel bandwidth deployed by the NW is not larger than the maximum bandwidth supported by RedCap UEs, there is no need for a UE capable of up to 20MHz BW to report it is a RedCap UE, which will have lower performance. Therefore, it is reasonable to indicate the RedCap type per-band. If FG 28-1 is specified per band, there is no need of FDD/TDD differentiation and no need of FR1/FR2 differentiation**Proposal 7: The indication type for 28-1 should be per band.*** **There is no need for FDD/TDD differentiation and no need of FR1/FR2 differentiation**
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| [6] | ZTE, Sanechips | According to the current discussion, the separate initial UL BWP in TDD and FDD is supported. And the separate initial DL BWP in TDD is also supported [4].

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| **Agreement in RAN1 #106e-bis*** **For a cell that allows a RedCap UE to access, network can configure a separate initial UL BWP for RedCap UEs in SIB**
	+ **It can be used both during and after initial access.**
	+ **It is no wider than the maximum RedCap UE bandwidth.**
	+ **It is always configured if the initial UL BWP for non-RedCap UEs is wider than the maximum RedCap UE bandwidth**
	+ **This applies to both TDD and FDD (including FD FDD and HD FDD) cases**
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| **Working Assumption in RAN1 #106e-bis*** **For a cell that allows a RedCap UE to access, network can configure a separate initial DL BWP for RedCap UEs in SIB.**
	+ **Working assumption: It can be used during initial access**
	+ **It can be used after initial access.**
	+ **It is no wider than the maximum RedCap UE bandwidth.**
	+ **FFS: It is always configured if the initial DL BWP for non-RedCap UEs is wider than the maximum RedCap UE bandwidth.**
	+ **This applies to both TDD and FDD (including FD FDD and HD FDD) cases.**
	+ **Working assumption: It applies at least after initial access for FR1 when MIB configured CORESET#0 is included**
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For RedCap UE, if the separate initial UL BWP is used during initial access in TDD, for the center frequency alignment, the separate initial DL BWP is also needed. If the separate initial DL BWP can be used during initial access, compared with non-RedCap UE, it can be viewed as a new UE capability. For example, if the SSB is not expected during the RA procedure, the UE may need to retune to the non-RedCap CORESET0 to receive the SSB for SIB update during initial access. Moreover, it should be mandatory since it is used before UE capability report. ***Proposal 16: For RedCap UE, separate DL initial BWP used in initial access for paging or RAR is a basic feature group or a basic component in FG28-1.***Additionally, for the RedCap UE support, ‘Per UE’ or ‘Per band’ need further decision. If a RedCap UE is defined based on ‘Per band’, it means a UE equipped with 20MHz bandwidth and 1Rx would be a RedCap UE in a band and be a non-RedCap UE in another band. Obviously, it is impossible that a UE equipped with 20MHz bandwidth and 1Rx would be a non-RedCap UE. Moreover, if a RedCap UE is viewed as ‘non-RedCap UE’ in a band, how this UE can support the non-RedCap UE capabilities. In another word, if a UE is equipped with all the non-RedCap UE capabilities and this UE is viewed as the RedCap UE in a band, this UE is totally exceed the capabilities defined in the RedCap WID scope for complexity/cost reduction. So, the FG28-1 RedCap UE should be ‘Per UE’. ***Proposal 19: FG 28-1 RedCap UE should be ‘Per UE’ configured.*** |
| [7] | Spreadtrum Communications | For whether to add any other basic features for RedCap UEs, we do not see the other basic features for RedCap UEs.It is proposed in [4] to define two FGs for operation with or without SSB/CSS in a UE-specific BWP similar as FG 6-1 and FG 6-1a. Operation without SSB in a UE-specific BWP needs the RedCap UEs to retune RF autonomously for AGC/sync/measurement, and thus it is a separate capability.FG 6-1 and FG 6-1a are listed as follows.

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| FG 6-11) 1 UE-specific RRC configured DL BWP per carrier2) 1 UE-specific RRC configured UL BWP per carrier3) RRC reconfiguration of any parameters related to BWP4) BW of a UE-specific RRC configured BWP includes BW of CORESET#0 (if CORESET#0 is present) and SSB for PCell/PSCell (if configured) and BW of the UE-specific RRC configured BWP includes SSB for SCell if there is SSB on SCellFG 6-1aBW of UE-specific RRC configured BWP may not include BW of the CORESET#0 (if CORESET#0 is present) and SSB for PCell/PSCell (if configured) and BW of the UE-specific RRC configured BWP may not include SSB for SCell |

FG for operation with SSB/CSS in a UE-specific BWP can be written as follows.

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| BW of a UE-specific RRC configured BWP includes BW of CORESET associated to CSS (if CORESET associated to CSS is present) and SSB, where CSS is SIB1, OSI, RAR or paging CSS |

FG for operation with SSB/CSS in a UE-specific BWP can be a separate FG, e.g. FG 28-4, or merged with the FG 6-1.***Proposal 3: FG for operation with SSB/CSS in a UE-specific BWP can be a separate FG, e.g. FG 28-4, or combined with the FG 6-1.***FG for operation without SSB/CSS in a UE-specific BWP can be written as follows.

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| BW of UE-specific RRC configured BWP may not include BW of the CORESET associated to SIB1, OSI, RAR or paging CSS (if SIB, OSI, RAR or paging CSS is present) and SSB |

FG for operation without SSB/CSS in a UE-specific BWP can be a separate FG, e.g. FG 28-4a, or merged with the FG 6-1a.***Proposal 4: FG for operation without SSB/CSS in a UE-specific BWP can be a separate FG, e.g. FG 28-4a, or combined with the FG 6-1a.***FGs for the BWP adaptation for RedCap UEs can be separate FGs, or merged with like FG 6-2/6-3/6-4 (shown in Appendix A.1).***Proposal 5: FGs for the BWP adaptation for RedCap UEs can be separate FGs, or merged with like FG 6-2/6-3/6-4.*** |
| [8] | Nokia, Nokia Shanghai Bell | * 28-1:
	+ - Per UE
		- FR1/2 differentiatoin
		- No need for xDD differentiation
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| [9] | OPPO | We had concluded that the FR1 RedCap UE support 20MHz, and FR2 RedCap UE support 100MHz. No additional bandwidths are further introduced. That FR differentiation can be implicitly determined. It would be natural to let the indication just per UE.It was also agreed that RedCap UEs do not support carrier aggregation or dual connectivity. However, we see no need to indicate “No CA” in the FG 28-1 description.***Proposal 2: For Maximum Supported bandwidth of RedCap UE, we can indicate it in per UE.*** |
| [10] | Intel Corporation | For some of the FGs #28-x identified so far, the FG type can be confirmed as “per band”, with exception of FG #28-1 which should be per UE. For FG #28 -1, the type should be “per UE” since the overall cost/complexity reduction benefit for a UE that may behave as non-RedCap UE in some bands while as a RedCap UE in some others is rather limited. More importantly, given the single carrier operation for RedCap UEs, what matters is if the UE reports itself a RedCap UE for the carrier in the band in which the UE may be currently camping on. Thus, a “per UE” capability indication for FG 28-1 is sufficient.**Proposal 1:*** *Confirm the type for FG 28-1 as “per UE”.*
* *Confirm the type for the following Rel-17 FGs for RedCap as “per band”:*
	+ *FGs #28-2, 28-3, 28-5 (if introduced).*

Next, on FDD/TDD differentiation, while FG #28-3 is applicable to FDD spectra and FR1 bands only, there is no need for FDD/TDD differentiation for FG #28-1 (for similar reasons why “per band” signaling is not necessary for FG #28-1) or for FG #28-2 if the latter is associated with “per band” type. FG #25-5, if introduced, can follow FG #28-2 in obviating need for TDD/FDD differentiation. **Proposal 3:*** *FDD/TDD differentiation is not necessary for FGs 28-1, 28-2, and 28-5 (if introduced).*
* *FG 28-3 is only applicable in FDD and FR1 bands.*
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| [11] | Xiaomi | One remaining issue for FG 28-1 is whether include other basic features into the component. In our understanding, the intension of FG 28-1is to define a RedCap UE type. For the RedCap UE type definition, the following agreements were made

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| **Agreement (RAN1#106e)**         A RedCap UE type from RAN1 point of view supports a maximum bandwidth of 20MHz for FR1 and 100MHz for FR2         Further discuss whether to capture also one or more of the following capabilities to RedCap UE type description* Supports either 1 or 2 Rx branches and corresponding maximum DL MIMO layers
* Supports either FD-FDD or Type A HD-FDD operation for FR1 FDD bands
* Supports either DL up to 64 QAM or up to 256 QAM for FR1
* Does not support CA/DC
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In our view, only including the maximum UE bandwidth is not sufficient considering the motivation to define RedCap UE type as described in the WID * for RedCap UE identification
* for constraining the use of those RedCap capabilities only for RedCap UEs
* for preventing RedCap UEs from using capabilities not intended for RedCap UEs including at least carrier aggregation, dual connectivity and wider bandwidths

In our understanding, the second bullet implies that non-RedCap may use the capability not included in the RedCap’s definition and the third bullet implies RedCap are not constrained for the capability which are not included the RedCap definition. For example, if reduced Rx is not included in the RedCap definition, the consequence may become that the RedCap may use the same number of Rx with non-RedCap e.g., 20MHz+4Rx in TDD band or the non-RedCap devices may support reduced number of Rx e.g., 100MHz+1Rx in TDD band. To avoid such situation, all the reduced capabilities RedCap supported should be included in the definition**Proposal 1: Include the following features in the components of FG 28-1*** **Supports either 1 or 2 Rx branches and corresponding maximum DL MIMO layers**
* **Supports either FD-FDD or Type A HD-FDD operation for FR1 FDD bands**
* **Supports either DL up to 64 QAM or up to 256 QAM for FR1**
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| [12] | CMCC | According to the agreements, FG 28-1 is supported as a basic FG for RedCap UE. And during the email discussion in RAN1#106b-e under AI 8.6.2, the following proposals are also made, and most of the companies can accept the proposal.**High Priority Proposal 5-1:** * + **Alt.2: Leave ‘Redcap Device Type’ definition to UE features of Redcap AI.**
		- **Note that: UE features that are defined as part of ‘Basic feature group’ for Redcap are included in the ‘Redcap Device Type’ definition.**

So as the Note says, the content of fourth column of FG28-1 will be included in the ‘Redcap Device Type’ definition,* 1. Maximum FR1 RedCap UE bandwidth is 20 MHz.
* 2. Maximum FR2 RedCap UE bandwidth is 100 MHz.
* FFS whether to add any other basic features for RedCap UE

The RedCap Device type related agreements were made in RAN1#106e as following. Agreements: [38.304, 38.306, 38.331]* A RedCap UE type from RAN1 point of view supports a maximum bandwidth of 20MHz for FR1 and 100MHz for FR2
* Further discuss whether to capture also one or more of the following capabilities to RedCap UE type description
	+ Supports either 1 or 2 Rx branches and corresponding maximum DL MIMO layers
	+ Supports either FD-FDD or Type A HD-FDD operation for FR1 FDD bands
	+ Supports either DL up to 64 QAM or up to 256 QAM for FR1
	+ Does not support CA/DC

To our understanding, the definition of RedCap UE type is to differentiate it from non-RedCap devices, and give a picture of key capabilities that RedCap devices support. As the WID describes, the motivation for RedCap UE type definition is ”*Specify definition of one RedCap UE type including capabilities for RedCap UE identification and for constraining the use of those RedCap capabilities only for RedCap UEs, and preventing RedCap UEs from using capabilities not intended for RedCap UEs including at least carrier aggregation, dual connectivity and wider bandwidths*.” To constrain the use of those RedCap capabilities only for RedCap UEs and prevent RedCap UEs from using capabilities not intented for them, it should be clear enough that what RedCap capabilities they are supposed to use for RedCap UEs. So the minimum set of the reduced capabilities that characterize RedCap devices should be included in the type definition.Among the capabilities listed in the above agreements, does not support CA/DC has been captured in FG28-1. At least the number of Rx branches should also be captured in the fourth column of FG28-1. Otherwise, a RedCap UE may not indicate its support of FG28-2, then this will not align with the RedCap capability.**Proposal 1: Add the following component in the fourth column of FG28-1,*** **Supports either 1 or 2 Rx branches and corresponding maximum DL MIMO layers.**

Besides this, we think separate initial UL/DL BWP and early identification are also basic UE features.* Separate initial UL/DL BWP

According to agreements made in RAN1#106b-e, network can configure separate initial UL/DL BWP for RedCap UEs by SIB which is before UE capability signaling, so RedCap should always support separate initial DL/DL BWP configuration, this should be a basic feature for RedCap UE. Agreement: [38.213, 38.331]* For a cell that allows a RedCap UE to access, network can configure a separate initial UL BWP for RedCap UEs in SIB
	+ It can be used both during and after initial access.
	+ It is no wider than the maximum RedCap UE bandwidth.
	+ It is always configured if the initial UL BWP for non-RedCap UEs is wider than the maximum RedCap UE bandwidth
	+ This applies to both TDD and FDD (including FD FDD and HD FDD) cases

Working Assumption: [38.213, 38.331]* For a cell that allows a RedCap UE to access, network can configure a separate initial DL BWP for RedCap UEs in SIB.
	+ Working assumption: It can be used during initial access
	+ It can be used after initial access.
	+ It is no wider than the maximum RedCap UE bandwidth.
	+ FFS: It is always configured if the initial DL BWP for non-RedCap UEs is wider than the maximum RedCap UE bandwidth.
	+ This applies to both TDD and FDD (including FD FDD and HD FDD) cases.
	+ Working assumption: It applies at least after initial access for FR1 when MIB configured CORESET#0 is included

**Proposal 2: Separate UL/DL initial BWP is a basic component that should be included in FG28-1.** |
| [13] | Samsung | Based on current status, there is no need to merge other FG 28-x to FG 28-1. However, there are some other on BWP related operation. Whether to update the description of FG28-1 can based on the outcome of AI 8.6.1. 1. For the Type, we are fine with “Per UE”, and with per UE, there is no need to differentiate FDD/TDD. For the differenation of FR1 and FR 2, in our understanding, this features is a flag to report as whether this UE is a RedCap UE or not. Since UE will report the supporting bands in other IE, therefore, for the need of FR1/FR2 differention, it can be No.We are also fine for the note to descript that RedCap UEs do not support CA and DC, which is align with WID. And this can be optional features, since this will not require all the UE to be able operates as RedCap UE. ***Proposal #1: Comfirm the need of FDD/TDD differentiation and need of FR1/FR2 differentiation as “No”, the note to not support CA/DC and optional featuers. Keep the FFS for componets for current ongoing discussion together with consequence part as further study.***  |
| [14] | Apple | One FFS aspect for FG 28-1 is whether to add other UE features. In our view, there is no need to merge FG 28-2 and FG 28-3 into basic group FG 28-1 to provide desirable implementation flexibility for Redcap UEs to fulfil different peak data rate use cases and market demand. In addition, it should be noted that support of 1 Rx cannot be basic feature required for Redcap as UE implemented with 2 Rx does not necessarily meet the 1 Rx requirement. In addition to reduced BW, other basic FGs (e.g., support early indication of Redcap UE, NCD-SSB in a separate BWP etc.) can be merged into FG 28-1. Regarding the type of FG 28-1, we prefer to define it as ‘per Band’, which offers important flexibility for UE in terms of Redcap capability report considering the testing differences in licensed, unlicensed, NTN bands as well as FR1/FR2 bands. **Proposal 1**: **Consider adding the following basic FGs into FG 28-1:** * *Early indication of Redcap UE by separate PRACH resource or PRACH preamble or Msg3 in 4-step RACH procedure in a shared initial UL BWP (if not included in RAN2 FG list)*
* *The early indication in Msg1 can be configured to be enabled/disabled via SIB*
* *NCD-SSB in a sperate initial DL BWP that does not include CD-SSB.*

**Proposal 2**: **The type of FG 28-1 is defined as ‘per Band’.** As discussed in our companion paper [3], we propose to introduce an optional UE feature FG 28-x to indicate the support of DL BWP without SSB in RRC\_CONNECTED state, analogous to legacy FG 6-1A. **Proposal 6: Introduce a new FG 28-x that is used to indicate the support of a UE-specific DL BWP without SSB when UE is in RRC\_CONNECTED state.**  |
| [15] | NEC | It is FFS from RAN1#106bis-e whether to add any other basic features for RedCap UE to FG 28-1.FG28-1 concerns maximum channel bandwidth for RedCap UE. For legacy UE, maximum channel bandwidth belongs to UE RF feature. If FG 28-1 would also belong to UE RF feature, it would not be appropriate to include other features into FG 28-1.**Observation:*** If FG 28-1 would belong to UE RF feature, it would not be appropriate to include other features into FG 28-1.

For UE feature of maximum channel bandwidth for legacy UE (FG 2-1 of UE RF), CBW which shall be mandatorily supported is described in the FG. FG 28-1 would need such description, though it is up to RAN4.**Proposal:*** Add CBW which shall be supported by RedCap UE to FG 28-1

“For FR1, all the bandwidths up to 20 MHz listed in TS38.101-1 v17~~15~~.0.0 Table 5.3.5-1 for each band shall be mandatory ~~with a single CC~~. ~~The bandwidths listed in the slide #3 of R4-1805985 are mandatory with a single CC. 90MHz is optional for n41, n77, n78.~~For FR2, the set of mandatory CBW is 50, 100~~, 200~~ MHz”As discussed in agenda 8.6.1.1, initial DL BWP operation for RedCap UE would likely be different from legacy UE, which may include no CORESET#0. So, some FG description would be needed.**Observation:*** Some description about UE feature of initial DL BWP operation for RedCap UE may be needed

On the other hand, for legacy UE, there is no feature group for initial BWP operation.Initial DL BWP for legacy UE always includes CORESET#0 and SSB for PCell. On the other hand, initial DL BWP for RedCap UE either includes CORESET#0 and “SSB for PCell” (CD-SSB), or does not include CORESET#0 and “SSB for PCell” while it includes another common CORESET and another additional SSB (option 2 for SSB transmission). Considering there is no feature group of initial DL BWP for legacy UE while initial DL BWP operation for RedCap UE would be likely different from legacy UE and essential, it can be considered to add initial DL BWP operation to FG 28-1.**Proposal:*** Initial DL BWP operation for RedCap UE can be included in FG 28-1

**FG 6-1/FG 6-1a**This FG concerns UE-specific RRC configured DL BWP which contains dedicated configuration.

|  |  |  |
| --- | --- | --- |
| 6-1 | Basic BWP operation with restriction | 1) 1 UE-specific RRC configured DL BWP per carrier2) 1 UE-specific RRC configured UL BWP per carrier3) RRC reconfiguration of any parameters related to BWP4) BW of a UE-specific RRC configured BWP includes BW of CORESET#0 (if CORESET#0 is present) and SSB for PCell/PSCell (if configured) and BW of the UE-specific RRC configured BWP includes SSB for SCell if there is SSB on SCell |
| 6-1a | BWP operation without restriction on BW of BWP(s) | BW of UE-specific RRC configured BWP may not include BW of the CORESET#0 (if CORESET#0 is present) and SSB for PCell/PSCell (if configured) and BW of the UE-specific RRC configured BWP may not include SSB for SCell |

Regarding 6-1 4), bandwidth of a UE-specific RRC configured BWP for RedCap UE does not always include BW of CORESET#0 and SSB for PCell.If option2 for SSB transmission is agreed, a note for RedCap UE would be needed that BW of a UE-specific RRC configured BWP includes a common CORESET instead of CORESET#0 and additional SSB instead of SSB for PCell.**Proposal:*** In case option 2 is agreed in agenda item 8.6.1.1, add a note for RedCap UE to FG 6-1 for the case a RRC configured DL BWP does not include CORESET#0 and SSB for PCell but include a common CORESET and additional SSB for RRM

**Observation:*** In case option 1 is agreed in agenda item 8.6.1.1, FG 6-1a seems a basic RedCap feature.
 |
| [16] | NTT DOCOMO, INC. | * FG 28-1: RedCap UE
	+ Regarding FFS whether to add any other basic features for RedCap UE, we don’t see any other basic features to be included in FG 28-1. The feature of early indication of RedCap UE is RAN2-led item and should be discussed in RAN2.
	+ Report type of FG 28-1 should be per UE
		- We don’t think a UE operates as RedCap UE in a band but as non-RedCap UE in another band. UE can report its supported bands where it can operate as RedCap UE.
	+ FDD/TDD and FR1/FR2 differentiation are not necessary for FG 28-1
		- Same as above, we don’t think a UE operates as RedCap UE in a band but as non-RedCap UE in another band. UE can report its supported bands where it can operate as RedCap UE.
	+ Note of FG 28-1 should be kept
 |
| [17] | Qualcomm Incorporated | According to the WID for R17 RedCap UE [1], system should support deployment of RedCap UE in all FR1/FR2 bands for FDD and TDD. On the other hand, RedCap UE’s complexity reduction features, such as BW reduction, RX branch number reduction and duplex mode, are band-specific. Given the potential UE testing differentiation among licensed, unlicensed and NTN bands, by default the specification and capability signalling for R17 RedCap UE FG should be per band.***Proposal 1: By default, the specification and capability signalling for R17 RedCap UE FG should be “per band.”***In RAN1#105 meeting, RAN1 made the following agreement for R17 RedCap UE:**Agreements:*** A RedCap UE cannot be configured with a non-initial (DL or UL) BWP (i.e., a BWP with a non-zero index) wider than the maximum bandwidth of the RedCap UE.
	+ At least for FR1, FG 6-1 (“Basic BWP operation with restriction” as described in TR 38.822) is used as a starting point for the mandatory RedCap UE type capability.
		- This does not preclude support of FG 6-1a (“BWP operation without restriction on BW of BWP(s)” as described in TR 38.822) as a UE capability for RedCap UEs.

Based on the discussion in [3], a DL BWP#0 no wider than 20 MHz can always be configured by MIB or SIB for RedCap UE, which includes the CD-SSB and CORESET#0/CSS for RMSI/OSI/RA/paging, as shown by Figure 1. When the MIB or SIB configured initial DL BWP of RedCap UE includes CD-SSB and CORESET#0, the DL BWP#0 configured by Option 2, B2 of TS 38.331 is a RRC-configured BWP for RedCap UE supporting FG 6-1 (“Basic BWP operation with restriction” as described in TR 38.822). To avoid/reduce the spec impacts of SSB-less BWP outlined in [3], it is essential to transmit SSB in the RRC-configured DL BWP of RedCap UE, Therefore, we have the following proposals:***Proposal 2: In FR1, FG 6-1a should NOT be specified as a mandatory capability for RedCap UE.******Proposal 3: At least in FR1, a new FG for RRC-configured DL BWP can be specified for RedCap UE, which includes SSB but does not include the entire CORESET#0 configured by MIB/CD-SSB.**** ***FFS: if this FG should be mandatory or optional for RedCap UE***
 |
| [18] | MediaTek Inc. | **Basic FG:** In our view, the following features should be part of the RedCap UE type and should be part of FG28-1:* RedCap UEs are not allowed to support maximum UE bandwidth larger than 20MHz/100MHz in FR1/FR2.
* 1Rx should be mandatory for RedCap UEs. 2Rx is optional for RedCap UEs.
* RedCap UEs should at least support HD-FDD Type-A. FD-FDD is optional for RedCap UEs.

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| --- | --- | --- | --- | --- | --- | --- |
| **Index** | **Feature group** | **Components** | **Prerequisite FG** | **Type** | **Note** | **Mandatory/Optional** |
| 28-1 | RedCap UE | 1. Maximum FR1 RedCap UE bandwidth is 20 MHz2. Maximum FR2 RedCap UE bandwidth is 100 MHz3. 1Rx branch with 1 DL MIMO layer.4. Half-duplex FDD operation Type-A. |  | Per UE | RedCap UEs do not support carrier aggregation, dual connectivity or maximum UE BW larger than 20MHz/100MHz in FR1/FR2. | Basic FG for RedCap UE |

 |

## **Discussion**

**[FL1] High priority question 2-1:**

* **Companies are encouraged to provide views on whether to add any other basic features for RedCap UE into FG 28-1**
	+ Rx branch and DL MIMO layer
		- 1 Rx branch and 1 DL MIMO layer: Ericsson, MediaTek
		- Either 1 or 2 Rx branches and corresponding maximum DL MIMO layers: FUTUREWEI, Xiaomi, CMCC
	+ FDD operation
		- Half-duplex FDD operation type A in FDD bands: Ericsson, MediaTek
		- Either FD-FDD or Type A HD-FDD operation for FR1 FDD bands: Xiaomi
	+ DL modulation
		- Up to 64QAM for PDSCH: Ericsson
		- Either DL up to 64 QAM or up to 256 QAM for FR1: Xiaomi
	+ CBW which shall be supported by RedCap UE
		- FFS: NEC
	+ Not necessary: Huawei, HiSilicon, Spreadtrum, Samsung, Apple, DOCOMO,
	+ Note: BWP related feature will be discussed in questions 2-2/2-3
	+ Note: RedCap indication related feature will be discussed in question 6-1

|  |  |
| --- | --- |
| Company | Comment |
| Ericsson | In order for FG 28-1 to represent the basic RedCap UE type, it should include the following components beside the reduced UE bandwidth:* 1 Rx branch and 1 DL MIMO layer
* Half-duplex FDD operation type A in FDD bands
* Up to 64QAM for PDSCH
 |
| Qualcomm | We think max UE BW is the most essential component of basic FG 28-1, which should be specified/signaled as “per band.”For a cell that allows RedCap UE to access, if the basic FG serves as NW’s default assumptions for RedCap UE’s L1 capabilities (prior to UE capability signaling in connected mode), we agree with the comments of Ericsson. In addition, the MCS table of qam64 can also be included as part of the basic FG.  |
| Intel | None in addition to reduced UE BW.  |
| vivo | No need to add #Rx and duplex scheme to the basic FG. Open to consider “Up to 64QAM for PDSCH” |
| ZTE, Sanechips | We think the Rx info should be incorporated into the FG28-1 or FG2-3 is a basic feature group(mandatory) for RedCap UE. Otherwise, If the UE does not report the Rx info and early identification is not configured, the gNB would regard this RedCap UE as the non-RedCap UE, which would cause scheduling problem. |
| NEC | Assuming FG28-1 belong to L1 features, none of listed above should be added to FG28-1.A FG in UE RF to describe CBW which shall be supported by RedCap UE with maximum channel BW of 20MHz in FR1 and 100MHz in FR2-1 would be needed. We are not sure if features can be duplicated. |
| Samsung | So far we don’t think it is necessary to add other basic features. Rx and DL MIMO layer can be added in existing FGs without create new.HD-FDD can be a separate featuresDL modulation already agreed to be captured in existing FGs.  |
| DOCOMO | We don’t think any other feature should be included in FG 28-1.None of 1Rx or 2Rx is mandatory and none of HD-FDD or FD-FDD is mandatory for FR1 FDD bands. It was agreed in the last RAN1 meeting that optional support of DL 256QAM for FR1 is captured in existing FG. |
| Spreadtrum | No strong need to add other features |
| CMCC | Rx number and related MIMO layers should also be basic features, but it can be a separate FG labeling as basic feature group since the “type” may be different as FG28-1. |
| FUTUREWEI | As specified in the WID, a RedCap UE is the union of several complexity reduction features. The WID sets the maximum BW as well as the maximum number of layers. The maximum number of layers (expressed as “Up to 2 Rx branches”) should be added. |
| Nokia, NSB | We think Half-duplex FDD operation type A in FDD bands should be added, e.g. as a component to FG 28-1. Otherwise we do not see the need to add further basic features.  |
| FL2 | Summary of companies’ view* + Rx branch and DL MIMO layer
		- 1 Rx branch and 1 DL MIMO layer: Ericsson, MediaTek, Qualcomm
			* basic FG serves as NW’s default assumptions for RedCap UE’s L1 capabilities
		- Either 1 or 2 Rx branches and corresponding maximum DL MIMO layers: FUTUREWEI, Xiaomi
	+ FDD operation
		- Half-duplex FDD operation type A in FDD bands: Ericsson, MediaTek, Qualcomm, Nokia, NSB
			* basic FG serves as NW’s default assumptions for RedCap UE’s L1 capabilities
		- Either FD-FDD or Type A HD-FDD operation for FR1 FDD bands: Xiaomi
	+ DL modulation
		- Up to 64QAM for PDSCH (and 64QAM MCS table): Ericsson, Qualcomm
			* basic FG serves as NW’s default assumptions for RedCap UE’s L1 capabilities
		- Either DL up to 64 QAM or up to 256 QAM for FR1: Xiaomi
	+ CBW which shall be supported by RedCap UE
		- FFS: NEC
	+ Not necessary: Huawei, HiSilicon, Spreadtrum, Samsung, Apple, DOCOMO, Intel, vivo, CMCC (FG 28-2 as basic FG)
		- None of 1Rx or 2Rx is mandatory and none of HD-FDD or FD-FDD is mandatory for FR1 FDD bands.

Given that majority companies prefer not to add any other basic features for RedCap UE into FG 28-1, following proposal is made.**[FL2] High priority proposal 2-1:*** **Following features are not added into FG 28-1**
	+ **Supported Rx branches and corresponding maximum DL MIMO layers**
	+ **Supported FDD operation**
	+ **Supported maximum DL modulation order**
	+ **Note: Other basic features for RedCap UE can be supported as other FGs**
 |
| Ericsson | We can live with this proposal, although we would prefer to include all “incapabilities” in FG 28-1, so that FG 28-1 represents the simplest Rel-17 RedCap UE. |
| HW, HiSi | Agree.  |
| DOCOMO | We support the proposal |
| vivo | Y |
| Qualcomm | Support FL2 proposal |
| ZTE, Sanechips | We can accept this until FG2-3 for RedCap indicates it is mandatory with capability signalling and the prerequisite feature groups includes FG28-1. |
| Xiaomi | We can accept this proposal for progress |

**High priority question 2-2:**

* **Companies are encouraged to provide views on whether to add following FGs (or components in FG 28-1)**
	+ **On top of FG 6-1, for the operation with SSB in a UE-specific BWP for RedCap UEs**
	+ **On top of FG 6-1a, for the operation without SSB in a UE-specific BWP for RedCap UEs**
	+ **On top of FGs 6-2/6-3/6-4 for BWP adaptation for RedCap UEs**

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| --- | --- |
| Company | Comment |
| FL | This question can be discussed after some progress is made in AI 8.6.1.1. |
| Spreadtrum | It can be listed as a separate FG. Pending until AI 8.6.1.1 is also fine. |
|  |  |
|  |  |

**[FL1] High priority question 2-3:**

* **Companies are encouraged to provide views on whether to add FGs (or add components in FG 28-1) for separate initial DL/UL BWPs for RedCap UEs**

|  |  |
| --- | --- |
| Company | Comment |
| Ericsson | We are fine with listing support for separate initial DL/UL BWPs as components but not as separate FGs, since it be seen as a fundamental part of the support for reduced UE bandwidth. |
| Qualcomm | In our view, the initial DL BWP and the initial UL BWP can be separately discussed for RedCap UE.On a cell that allows both RedCap and non-RedCap UEs to access, if the SIB-configured initial DL/UL BWPs of non-RedCap UE are wider than the max BW of RedCap UE:* RedCap UE is not necessary to support a separate initial DL BWP, since the RedCap UE can always re-use the MIB-configured CORESET#0 as the initial DL BWP
* RedCap UE is needed to support a separate initial UL BWP configured by SIB, and the intra-slot FH of PUCCH within the initial UL BWP can be disabled by SIB as well. Besides, the center frequency of the separate initial UL BWP can be different from that of initial DL BWP in TDD.
 |
| Intel | Same view as Ericsson on capturing separate initial DL/UL BWPs.Additionally, we think the following should be added as a component for 28-1:* + *“For 4-step RACH, support of early identification of RedCap UE during Msg1 transmission”*

*This also relates to* **High priority question 6-1.** *In our view, the “sub-features” should be added as components to 28-1 and not as separate FGs.* |
| vivo | We think the separate initial DL and UL initial BWPs can be list as new FGs, rather than new component of 28-1. As they are considered as advanced UE features, the basic UE behavior is to share the initial DL and UL BWPs with non-RedCap UEs.  |
| ZTE, Sanechips | We are OK to add the separate initial DL/UL BWPs as the basic feature group or component in 28-1, since they are used before UE capability report.  |
| NEC | Same view as Ericsson. |
| Samsung | Can be based on the outcome of AI 8.6.1.1 |
| DOCOMO | If necessary, they should be captured as components in FG 28-1. If they are supported as separate FGs and not basic FG for RedCap UEs, gNB cannot configure separate initial DL/UL BWPs for RedCap UEs in SIB since gNB does not know the capabilities before the capability reporting. |
| Spreadtrum | Open to add it in FG 28-1 or in FG 28-x for BWP operation with or without SSB/CSS |
| CMCC | Support of separate UL/DL initial BWP is a basic component that should be included in FG28-1, and also the early indication function, which can be described as following similar as “2. msgA PRACH resource and format determination” is included in its FG9-1 for 2-step RACH.* RedCap dedicated PRACH resource or PRACH preamble determination;
* Receiving RACH related downlink channels in separated initial DL BWP if RACH related CSS/CORESET is configured
 |
| FUTUREWEI | For the separate initial UL BWP, it is necessary when the bandwidth of the initial UL BWP of a non-RedCap UE exceeds the maximum bandwidth of a RedCap UE. It should be considered as a component of 28-1.  |
| Nokia, NSB | It should not be a separate FG.  |
| FL2 | Summary of companies’ view* + Add FGs for separate initial DL/UL BWPs for RedCap UEs
		- Qualcomm (DL?), vivo
			* RedCap UE is not necessary to support a separate initial DL BWP, since the RedCap UE can always re-use the MIB-configured CORESET#0 as the initial DL BWP
			* As they are considered as advanced UE features, the basic UE behavior is to share the initial DL and UL BWPs with non-RedCap UEs.
	+ Add components in FG 28-1 for separate initial DL/UL BWPs for RedCap UEs
		- Ericsson, Qualcomm (UL?), Intel, ZTE, NEC, DOCOMO, [Spreadtrum], CMCC, FUTUREWEI (initial UL BWP)
			* fundamental part of the support for reduced UE bandwidth
			* RedCap UE is needed to support a separate initial UL BWP configured by SIB, and the intra-slot FH of PUCCH within the initial UL BWP can be disabled by SIB as well. Besides, the center frequency of the separate initial UL BWP can be different from that of initial DL BWP in TDD.
			* they are used before UE capability report
	+ Can be discussed based on the outcome from AI 8.6.1.1
		- Samsung

Given that majority companies prefer to add components in FG 28-1 for separate initial DL/UL BWPs for RedCap UEs, following proposal is made**[FL2] High priority proposal 2-3:*** **Following features are added as components in FG 28-1**
	+ **Separate initial DL BWP for RedCap UEs**
	+ **Separate initial UL BWP for RedCap UEs**
 |
| Ericsson | Ok (assuming that RAN1 confirms the working assumption to introduce separate initial DL BWP for RedCap UEs) |
| DOCOMO | We support the proposal |
| vivo | The FL2 proposal cannot be agreed until the resolution of NCD-SSB issue in AI 8.6.1.1 |
| Qualcomm | We have concerns for the FL2 proposal.For the separate initial DL BWP configured for RedCap UE, we’d like to wait for RAN1’s conclusion for AI 8.6.1.1 as well as the confirmation of RAN2 and RAN4. If RAN2 and RAN4 have concerns to support SIB-configured initial DL BWP without CD-SSB and the entire CORESET#0 (e.g. spec impacts too much for R17). |
| ZTE, Sanechips | OK. The discussion of AI 8.6.1.1 would impact on how to use Separate initial DL/UL BWP, but would not affect the configuration of Separate initial DL/UL BWP. |
| Xiaomi | Currently we can accept to add separate initial UL BWP in FG 28-1For the component of separate initial DL BWP, we need to wait for the progress of AI 8.6.1.1 |

**Medium priority question 2-4:**

* **Companies are encouraged to provide views on whether the type of FG 28-1 should be per UE or per band**
	+ Per UE: Ericsson, Huawei, HiSilicon, ZTE, Sanechips, Nokia, NSB, OPPO, Intel, Samsung, DOCOMO
	+ Per band: vivo, Guangdong Genius, Apple, Qualcomm

|  |  |
| --- | --- |
| Company | Comment |
| Qualcomm | It should be “per band” |
| Nokia, NSB | * + Per UE
	+ FR1/2 differentiatoin
	+ No need for xDD differentiation
 |
| vivo | It should be “per band”. As explained in our contribution R1-2111054, in TS 38.101 Table 5.3.5-1 many low frequency bands are defined with channel bandwidth of up to 20MHz, for example band n2/n5/n8, …. In these bands, since the channel bandwidth deployed by the NW is not larger than the maximum bandwidth supported by RedCap UEs, there is no need for a UE capable of up to 20MHz BW to report it is a RedCap UE, if the RedCap UE implements 2Rx and therefore can perform the same as non-RedCap UEs.  |

**Medium priority question 2-5:**

* **Companies are encouraged to provide views whether xDD/FRx differentiation is necessary for FG 28-1**
	+ FDD/TDD differentiation:
		- Necessary:
		- Not necessary: Ericsson, Huawei, HiSilicon, vivo, Guangdong Genius, Nokia, NSB, Intel, Samsung, DOCOMO
	+ FR1/FR2 differentiation:
		- Necessary: Nokia, NSB
		- Not necessary: Huawei, HiSilicon, vivo, Guangdong Genius, Nokia, NSB, Samsung, DOCOMO
		- FFS: Ericsson

|  |  |
| --- | --- |
| Company | Comment |
| FL | This question can be discussed after some progress is made in question 2-4. |
|  |  |
|  |  |

**Low priority question 2-6:**

* **Companies are encouraged to provide views on whether/how to revise any other contents in FG 28-1 which do not have capability signaling impacts**

|  |  |
| --- | --- |
| Company | Comment |
| Qualcomm | Do not support CA/DC can be added to FG 28-1. |
|  |  |
|  |  |

# **28-2: Number of UE Rx branches and DL MIMO layers for RedCap UE**

In [1], FG 28-2 is captured as below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between Ues (Sidelink WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
|  28. NR\_redcap | 28-2 | Number of UE Rx branches and DL MIMO layers for RedCap UE | 1. For a RedCap UE with 1 Rx branch, 1 DL MIMO layer is supported.2. For a RedCap UE with 2 Rx branches, 2 DL MIMO layers are supported. | 28-1 | Yes |  | Impact on UE complexity | Per band | No | No |  | For UE capability signalling, the number of Rx branches for RedCap is implicitly indicated by the corresponding capability parameter *maxNumberMIMO-LayersPDSCH* in the existing UE capability framework. Detailed signalling is up to RAN2. | Optional with capability signaling |

Following feedbacks are provided in contributions for the RAN1#107-e meeting.

|  |  |  |
| --- | --- | --- |
| [2] | Ericsson | To our understanding, it is likely that it will be desired to indicate support of different number of Rx branches for different bands.1. FG 28-2 (‘Number of UE Rx branches and DL MIMO layers for RedCap UE’’) is per band (or per FSPC if it is desired to align with legacy signaling solution).
 |
| [3] | Huawei, HiSilicon | FG 28-1: no other features needs to be added as discussed in [5]. And we think no need of FDD/TDD or FR1/FR2 differentiation, because UE type does not related to band or duplex mode. Also, channel bandwidth report in R15/16 does not have band or duplex mode differentiation, so does for RedCap UEs. FG 28-2: for non-RedCap UEs, *maxNumberMIMO-LayersPDSCH* is reported per *FeatureSetDownlinkPerCC*, which is reported per CC based on per band per BC. As RedCap UEs do not support CA, number of UE Rx branches and DL MIMO layers is reported per band is sufficient and reasonable. FG 28-3: it was discussed in SI stage that a HD-FDD UE can benefit from lower cost with removal of duplexer, which results in a hardware implementation of the UE without duplexer in any band. Thus, this can be per UE reported.***Proposal 2:*** *FG 28-1 and FG 28-3 to be reported per UE without xDD/FRx differentiation and FG 28-2 to be reported per band.* |
| [4] | FUTUREWEI | We have four observations with the revised formulation.***Observation 1.***1. ***FG 28-1 must include a basic feature for a reduced number of Rx branches***
2. ***FG 28-2 must be removed as indicated by RAN2***
3. ***FG 28-5 must be removed since UL 256QAM is not in the WID***
4. ***Capture Early Indication functionality***

FG 28-2FG 28-2 must be removed. According to [4] (yellow highlighting added)

|  |
| --- |
| …6. Do not introduce capability signalling on the supported Rx number for RedCap UE since the number of Rx branches for RedCap is implicitly indicated by the corresponding capability parameter maxNumberMIMO-LayersPDSCH in the existing UE capability framework; |

RAN2 specifically agreed NOT to introduce capability signaling for the supported Rx number. With such a clear statement from RAN2, we fail to understand why FG28-2 is still present. |
| [5] | vivo, Guangdong Genius | For FG 28-2, as captured and clarified in the note that the Detailed signalling is up to RAN2. We can keep FG 28-2 in brackets [] as it is informative. Regarding to the type, we are fine with either per FSPC to keep the consistency as for the capability of maxNumberMIMO-LayersPDSCH or per band. **Proposal 8: The Type of FG28-2 should be either per FSPC or per band.** |
| [6] | ZTE, Sanechips | For the Rx number, obviously, it is main character of RedCap UE. According to the RAN2 agreement, we do not need to add a new UE capability to indicate the Rx info and MIMO layer. If the legacy FG2-3 PDSCH MIMO layers is reused, it is not appropriate to set it as the mandatory since FG 28-1 RedCap UE is only an optional feature. Therefore, a modification for reusing FG2-3 PDSCH MIMO layers is expected.Moreover, similar as bandwidth, Rx information should be a basic component for RedCap UE since we cannot assume the RedCap UE is equipped with more than 2 Rx. Alternatively, setting the Rx number as the basic feature group for RedCap is also appropriate.***Proposal 18: Rx number should be a basic component or a basic feature group for RedCap UE.*** |
| [7] | Spreadtrum Communications | For RedCap UE, the minimum number of Rx antennas and the maximum number of DL MIMO layers can be reduced to 1 or 2. The related objectives in the WID [2] are listed as follows.

|  |
| --- |
| * Reduced minimum number of Rx branches:
	+ For frequency bands where a legacy NR UE is required to be equipped with a minimum of 2 Rx antenna ports, the minimum number of Rx branches supported by specification for a RedCap UE is 1. The specification also supports 2 Rx branches for a RedCap UE in these bands.
	+ For frequency bands where a legacy NR UE (other than 2-Rx vehicular UE) is required to be equipped with a minimum of 4 Rx antenna ports, the minimum number of Rx branches supported by specification for a RedCap UE is 1. The specification also supports 2 Rx branches for a RedCap UE in these bands.
	+ A means shall be specified by which the gNB can know the number of Rx branches of the UE.
* Maximum number of DL MIMO layers:
	+ For a RedCap UE with 1 Rx branch, 1 DL MIMO layer is supported.
	+ For a RedCap UE with 2 Rx branches, 2 DL MIMO layers are supported.
 |

As agreed in the WI phase, the number of Rx antenna for RedCap is implicitly indicated by the corresponding capability parameter *maxNumberMIMO-LayersPDSCH* in the existing UE capability framework. When the parameter ***maxNumberMIMO-LayersPDSCH* is** absent, the UE support 1Rx and 1 MIMO layer.On the other hand, there is no consensus to specify solutions to reduced PDCCH blocking caused by the large AL due to the reduced number of Rx antennas. Hence, the compact DCI formats (i.e. DCI 0\_2/1\_2) are still optional. In other words, DCI format 0\_0/1\_0 and DCI format 0\_1/1\_1 are still mandatory for RedCap UEs similar as legacy UEs.Therefore, FG 28-2 may not be defined for the reduced Rx antenna/MIMO layer, and the reduced Rx antenna/MIMO layer can be captured in FG 2-3 for “PDSCH MIMO layers”.***Proposal 1: The reduced Rx antenna/MIMO layer can be captured in FG 2-3 for “PDSCH MIMO layers”.*** |
| [9] | OPPO | UE have to report one of the supported maximum Rx branches. However, the signalling about 28-2 can be implicitly decided by number of MIMO layer. In the WI phase, we already conclude that the number of RX antenna for RedCap UE is implicitly indicated by the corresponding capability parameter of MIMO layer. The current parameter is *maxNumberMIMO-LayersPDSCH*.***Proposal 2: For Maximum Supported number of UE RX branches, it is indicated by existing definition of MIMO layer with necessary extension.*** |
| [11] | Xiaomi | The intension of this FG is to indicate the number of Rx branches and DL MIMO layers. Since RedCap support at least 1 Rx/MIMO layer, then there is no need to report the number of 1Rx/MIMO layer. Only when the number of Rx/MIMO layer is 2, RedCap could report the support of 2 Rx/MIMO layers. Considering this point, we suggest to perform the following update for FG 28-2**Proposal 2: Update FG 28-2 as follows** * **Update the feature group as “2 Rx branches and DL MIMO layers for RedCap”**
* **Update the Components as “2 Rx branches with maximum 2 DL MIMO layers for RedCap UE”**
* **Update the Consequence if the feature is not supported by the UE as “NW assumes the RedCap UE only support 1 Rx branches with maximum 1 DL MIMO layer”**
 |
| [13] | Samsung | There were some discussions on whether FG 28-2 can be deleted or not. We think this be discussed in RAN 2. RAN 2 agreed in RAN 2 #115 e that there is no need to introduce capability signalling on the supported Rx number for RedCap. Do not introduce capability signalling on the supported Rx number for RedCap UE since the number of Rx branches for RedCap is implicitly indicated by the corresponding capability parameter maxNumberMIMO-LayersPDSCH in the existing UE capability framework;Therefore, we think this feature can be up to RAN 2. And from RAN 1 perspective, there is no need to keep it. ***Proposal #2: Leave FG 28-2 to RAN 2.*** |
| [14] | Apple | In RAN1 105-e meeting, the following was agreed:

|  |
| --- |
| **Agreement:****For UE capability signalling, the number of Rx branches for RedCap is implicitly indicated by the**corresponding capability **parameter *maxNumberMIMO-LayersPDSCH* in the existing UE capability framework.*** **Detailed signalling is up to RAN2**
 |

In RAN2 115 e-meeting, the following was agreed in offline discussions over email: 1. Do not introduce capability signalling on the supported Rx number for RedCap UE since the number of Rx branches for RedCap is implicitly indicated by the corresponding capability parameter *maxNumberMIMO-LayersPDSCH* in the existing UE capability framework;

Based on the RAN2 agreement, our view is that the FG 28-2 in [1] is not needed. In addition, the existing FG 2-3 *maxNumberMIMO-LayersPDSCH* is defined as per FSPC, instead of ‘per band’, which should be kept for Redcap UEs. **Proposal 3: Remove FG 28-2 in [1] and use the capability parameter *maxNumberMIMO-LayersPDSCH (FG2-3)* in the existing UE capability framework to indicate MIMO layers and Rx branches as agreed by RAN1 and RAN2.** **Proposal 4: Add a note in 38.306 for *maxNumberMIMO-LayersPDSCH* IE that is also used to indicate the number of Rx branches supported by the Redcap UE.** |
| [15] | NEC | Number of Rx branches and corresponding maximum number of DL MIMO layers is supposed to be per band. On the other hand, FG 2-3 is FSPC. Whether FG 2-3 can be reused would need discussion while we are fine it is up to RAN2.**Proposal:*** Regarding FG 28-2, it can be up to RAN2 whether FG 2-3 (which is FSPC) can be reused for RedCap UE feature of number of Rx branches and maximum number of DL MIMO layers (which is considered per band)
 |
| [16] | NTT DOCOMO, INC. | * FG 28-2: Number of UE Rx branches and DL MIMO layers for RedCap UE
	+ FG 28-2 should be kept for “Number of UE Rx branches and DL MIMO layers for RedCap UE”. As clarified in the note in FG 28-2, how to indicate the number of UE Rx branches and DL MIMO layers for RedCap UE is up to RAN2. RAN1 can inform RAN2 what information (type, xDD/FRx differentiation, etc.) should be reported from RedCap UE
	+ Components of FG 28-2 should be kept
	+ FG 28-1 should be the prerequisite FG of FG 28-2
	+ Report type of FG 28-2 should be per band
		- FDD/TDD and FR1/FR2 differentiation are not applicable to FG 28-2
	+ Note of FG 28-2 should be kept
 |
| [17] | Qualcomm Incorporated | According to the WID for R17 RedCap UE [1], system should support deployment of RedCap UE in all FR1/FR2 bands for FDD and TDD. On the other hand, RedCap UE’s complexity reduction features, such as BW reduction, RX branch number reduction and duplex mode, are band-specific. Given the potential UE testing differentiation among licensed, unlicensed and NTN bands, by default the specification and capability signalling for R17 RedCap UE FG should be per band.***Proposal 1: By default, the specification and capability signalling for R17 RedCap UE FG should be “per band.”*** |
| [18] | MediaTek Inc. | **FG28-2:** The existing NR FG “*maxNumberMIMO-LayersPDSCH”* can be used to report if the UE supports 2Rx. |

## **Discussion**

**[FL1] High priority question 3-1:**

* **Companies are encouraged to provide views on whether to remove FG 28-2 and add a note in FG2-3 (maxNumberMIMO-LayersPDSCH) on how the existing FG should be interpreted for RedCap UEs**
	+ Remove: FUTUREWEI, ZTE, Sanechips Spreadtrum, OPPO, Samsung, Apple, MediaTek
	+ Keep in square brackets: vivo, Guangdong Genius, DOCOMO

|  |  |
| --- | --- |
| Company | Comment |
| Ericsson | Note that FG 2-3 is reported per FSPC.We are fine with replacing FG 28-2 with a note in FG 2-3 assuming that “1 Rx branch and 1 DL MIMO layer” is included as a component of FG 28-1.If FG 28-1 does not include “1 Rx branch and 1 DL MIMO layer” as a component, then we prefer to continue the discussion regarding FG 28-2 (keep in square brackets) until a satisfactory solution has been found. |
| Qualcomm | We prefer to keep FG 28-2, and the report type should be per band |
| Intel | Same view as Ericsson. Also, fine to keep FG 28-2 with per band reporting. |
| vivo | It can be kept.  |
| ZTE, Sanechips | New feature for Rx is not needed according to RAN2 conclusion. We do not see any necessity to keep 28-2 and revert the agreement from RAN2.It is OK to add a note in FG2-3 (maxNumberMIMO-LayersPDSCH) on how the existing FG should be interpreted for RedCap UEs. Moreover, for RedCap, this FG should be mandatory or viewed as the basic group. If it is optional and UE does not report this FG, it would cause the gNB scheduling problem. Alternatively, add the Rx info as the component in FG28-1 and take FG 2-3 as optional capability for RedCap, is also OK with us. |
| NEC | We are not sure if FG2-3 can be reused for “per band” capability. |
| Samsung | Remove FG 28-2 and add not in FG 2-3 to define the number of MIMO layers for RedCap |
| DOCOMO | At least for indicating the supported number of Rx per band, one of the followings should be agreed. In either option, detailed signalling is up to RAN2* Option 1: Keep FG 28-2 and inform RAN2 that supported number of Rx is reported per band in the type column
* Option 2: Remove FG 28-2 and add a note in FG 2-3 that supported number of Rx is reported per band for RedCap UE
 |
| FUTUREWEI | We prefer to remove 28-2 and fine to a note FG 2-3. It is unacceptable to add only 1 RX branch to 28-1, this is against our earlier agreement for the signaling of the number of RX branches. |
| Nokia, NSB | It is not clear what would be the benefit of signaling 28-2 in addition to 2-3. A per band indication here would not really save overhead given that 2-3 is mandatory already, with a finer granularity. |
| FL2 | Summary of companies’ view* + Remove: FUTUREWEI, ZTE, Sanechips Spreadtrum, OPPO, Samsung, Apple, MediaTek, [Ericsson], [DOCOMO], Nokia, NSB
		- New feature for Rx is not needed according to RAN2 conclusion
	+ Keep in square brackets: vivo, Guangdong Genius, [DOCOMO], Ericsson, Qualcomm, Intel, [NEC],
		- FG 2-3 is reported per FSPC. FG 28-2 should be per band

Given that removing removing FG 28-2 and add a note in FG 2-3 got more support, following proposal is made.**[FL2] High priority propsoal 3-1:*** **Remove FG 28-2 and add a note in FG2-3 (maxNumberMIMO-LayersPDSCH) on how the existing FG should be interpreted for RedCap UEs**

Companies are also invited to provide the text proposal for the note in FG 2-3 on how the existing FG should be interpreted for RedCap UEs |
| Ericsson | Ok |
| HW, HiSi | We prefer per band report while can accept FL proposal.  |
| DOCOMO | We are fine with the proposal.Text proposal for FG 2-3: RedCap UE supports either 1 or 2 Rx and corresponding maximum DL MIMO layers. Supported number of Rx is reported per band for RedCap UE |
| vivo | OK |
| HW, HiSi02 | Reading some of the previous comments, we want to clarify that per band report is sufficient and can save overhead signaling, since a RedCap may not need to report the MIMO layers anymore once Rx number is separately reported, unlike non-RedCap UEs, because there is direct association of number of Rx and number of MIMO layers in DL for RedCap UEs.We noticed that RAN2 is also discussing the signaling design for this issue. So we propose to leave it to RAN2 - what RAN1 needs to be agreed regarding FG 28-2 is both 1Rx and 2Rx are optionally supported by RedCap and RAN1 consider it can be per-band reported (then for sure per FSBC is possible if RAN2 consider to reuse an existing signalling). |
| Qualcomm | Agree with the comments of DOCOMO. |
| ZTE, Sanechips | We are fine with the proposal. The following text proposal for FG 2-3 is OK for us: RedCap UE supports either 1 or 2 Rx and corresponding maximum DL MIMO layers.Additionally, for RedCap UE, it is mandatory with capability signalling and the prerequisite feature groups includes FG28-1.Last, whether it is reported ‘Per band’ or ‘per FSPC’ can be further discussed. |
| Xiaomi | We are OK with FL’s proposal  |

**High priority question 3-2:**

* **Companies are encouraged to provide views on** **whether to revise FG 28-2 to “2 Rx branches and DL MIMO layers for RedCap” to indicate the support of 2 Rx branches/2 DL MIMO layers for RedCap UE**

|  |  |
| --- | --- |
| Company | Comment |
| FL | This question can be discussed after some progress is made in questions 2-1 and 3-1. |
| FUTUREWEI | This proposal is against the agreements in RAN1 and RAN2.**Agreements:** [38.306, 38.331]* **For UE capability signalling, the number of Rx branches for RedCap is implicitly indicated by the** corresponding capability **parameter *maxNumberMIMO-LayersPDSCH* in the existing UE capability framework.**
	+ **Detailed signalling is up to RAN2**
 |

**Medium priority question 3-3:**

* **Companies are encouraged to provide views on whether the type of FG 28-2 should be per band or per FSPC**
	+ Per band: Ericsson, Huawei, HiSilicon, vivo, Guangdong Genius, DOCOMO, Qualcomm
	+ Per FSPC: [Ericsson], vivo, Guangdong Genius

|  |  |
| --- | --- |
| Company | Comment |
| Nokia, NSB | If needed, it should be per band. But see answer to 3-1 first. |
|  |  |
|  |  |

**Low priority question 3-4:**

* **Companies are encouraged to provide views on whether/how to revise any other contents in FG 28-2 which do not have capability signaling impacts**

|  |  |
| --- | --- |
| Company | Comment |
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|  |  |
|  |  |

# **28-3: Half-duplex FDD operation for RedCap UE**

In [1], FG 28-3 is captured as below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (Sidelink WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 28. NR\_redcap | 28-3 | Half-duplex FDD operation type A for RedCap UE | 1. Half-duplex FDD operation (instead of full-duplex FDD operation) type A for RedCap UE | 28-1 | Yes |  | UE is assumed to support FD-FDD in FDD bands | Per band | FDD only | FR1 only |  |  | Optional with capability signaling |

Following feedbacks are provided in contributions for the RAN1#107-e meeting.

|  |  |  |
| --- | --- | --- |
| [2] | Ericsson | To our understanding, it is likely that it will be desired to indicate support of different duplex modes (HD-FDD/FD-FDD) for different FDD bands, so we propose to remove the square brackets.1. FG 28-3 (‘Half-duplex FDD operation for RedCap UE’) is per band.
 |
| [3] | Huawei, HiSilicon | FG 28-1: no other features needs to be added as discussed in [5]. And we think no need of FDD/TDD or FR1/FR2 differentiation, because UE type does not related to band or duplex mode. Also, channel bandwidth report in R15/16 does not have band or duplex mode differentiation, so does for RedCap UEs. FG 28-2: for non-RedCap UEs, *maxNumberMIMO-LayersPDSCH* is reported per *FeatureSetDownlinkPerCC*, which is reported per CC based on per band per BC. As RedCap UEs do not support CA, number of UE Rx branches and DL MIMO layers is reported per band is sufficient and reasonable. FG 28-3: it was discussed in SI stage that a HD-FDD UE can benefit from lower cost with removal of duplexer, which results in a hardware implementation of the UE without duplexer in any band. Thus, this can be per UE reported.***Proposal 2:*** *FG 28-1 and FG 28-3 to be reported per UE without xDD/FRx differentiation and FG 28-2 to be reported per band.* |
| [5] | vivo, Guangdong Genius | For 28-3 of Half-duplex FDD operation type A for RedCap UE, the type should be per band, as the implementation could be different across wide range of different FDD bands.**Proposal 9: The Type of FG28-3 should be per band.** |
| [7] | Spreadtrum Communications | Furthermore, for the granularity that the “type” definition for HD-FDD feature, we understand that it is more flexible to indicate support of different duplex modes (HD-FDD/FD-FDD) for different FDD bands. Therefore, we prefer “per band” for HD-FDD feature.***Proposal 2: for*** ***FG 28-3, the granularity is per band.*** |
| [8] | Nokia, Nokia Shanghai Bell | * 28-3:
	+ - Per UE
		- FR1/2 differentiation
		- No need for xDD differentiation
 |
| [9] | OPPO | A RedCap HD-FDD UE is hardware designed as Type A HD-FDD, though it is only applicable to FDD bands. Thus, it is not expected that a UE would report ‘Yes’ on FDD band X but ‘No’ on FDD band Y. This capability can be per UE reported. ***Proposal 3: For FG 28-3, clarify it as Type A HD-FDD and per UE reported.***However, the indication of 28-3 cannot replace the earlier identification of RedCap UE is mandated with the Half duplex capability. This can be discussed in the others agenda. |
| [11] | Xiaomi | In our understanding, once the duplexer is replaced by a switch, all the bands will be impacted. From this point the “Type” column should be “per UE” rather than “per band”.**Proposal 3: Update FG 28-4 as follows** * **Change the Type from “per band” to “per UE”**
 |
| [13] | Samsung | From implementation point of view, half-duplex FDD operation is determinated based on hardware. It is not a band related feature. Therefore, they type of feature 28-3 should be Per UE. Besides, this feature is FDD specific features and can be applied for FR1 only. ***Proposal #3: Feature 28-3 is defined per UE other than per band, and confirm FG28-3 is “FDD only” and “FR 1 only”*** |
| [16] | NTT DOCOMO, INC. | * FG 28-3: Half-duplex FDD operation type A for RedCap UE
	+ Report type of FG 28-3 should be per band for more flexibility to indicate the support of either HD-FDD or FD-FDD for different FDD bands.
		- FG 28-3 is applicable only to FR1 FDD bands
 |
| [17] | Qualcomm Incorporated | According to the WID for R17 RedCap UE [1], system should support deployment of RedCap UE in all FR1/FR2 bands for FDD and TDD. On the other hand, RedCap UE’s complexity reduction features, such as BW reduction, RX branch number reduction and duplex mode, are band-specific. Given the potential UE testing differentiation among licensed, unlicensed and NTN bands, by default the specification and capability signalling for R17 RedCap UE FG should be per band.***Proposal 1: By default, the specification and capability signalling for R17 RedCap UE FG should be “per band.”***In RAN1#106bis-e meeting, it was agreed to support Type-A HD-FDD as an optional FG for R17 RedCap UE. If a RedCap UE’s capability signalling indicates it does not support Type-A HD-FDD on paired spectrum, NW assumes the RedCap UE supports FD-FDD on paired spectrum. On the other hand, if a FD-FDD capable RedCap UE supports the collision handling procedures specified for Type-A HD-FDD UE, it can fall-back to Type-A HD-FDD based on the RRC reconfiguration of NW, which is beneficial for UE power saving and inter-cell interference mitigation [2]. ***Proposal 4: When operating on paired spectrum, a FD-FDD RedCap UE can indicate whether it supports fall-back to Type-A HD-FDD operation.*** ***Proposal 5: If a R17 FD-FDD RedCap UE has signalled its capabilities to support Type-A HD-FDD operation on paired spectrum, the RedCap UE is expected to receive a dedicated RRC configuration for the duplex mode.**** ***FFS: if the duplex mode can be included in the RRC configurations of BWP***
 |
| [18] | MediaTek Inc. | **Defining “incapability” UE features:** According to RAN2 LS ‎[3] that provided guidelines for UE capability definitions, RAN1 should avoid defining “incapability” UE features. The definition of the capability should not say that “a UE setting the bit does not support feature X”. The relevant guidelines from RAN2 LS is copied below:

|  |
| --- |
| **1 Avoid defining “incapability” bits as they may cause interpretation issues**The definition of the capability should not say that “a UE setting the bit does not support Rel-16 feature X”. Such statements caused a lot of problems in Rel-15. One example was the *pucch-F0-2WithoutFH* that indicates that “the UE does **not** support PUCCH formats 0 and 2 without frequency hopping”.  |

In our view, the current FG28-3 is not aligned with RAN2 LS guidelines. A UE reporting FG28-3 is effectively indicating that it doesn’t support FD-FDD in FDD bands (i.e. “incapability” of FD-FDD). Hence, FG28-3 should be removed and an optional UE capability for supporting FD-FDD should be added

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Index** | **Feature group** | **Components** | **Prerequisite FG** | **Type** | **Note** | **Mandatory/Optional** |
| 28-3 | Full-duplex FDD operation for RedCap UE | 1. Full-duplex FDD operation for RedCap UE | 28-1 | [Per band] |  | Optional with capability signaling |

 |

## **Discussion**

**[FL1] High priority question 4-1:**

* **Companies are encouraged to provide views on whether FG 28-3 should be revised as “Full ~~Half~~-duplex FDD operation ~~type A~~ for RedCap UE” to avoid defining “incapability” bits**

|  |  |
| --- | --- |
| Company | Comment |
| Ericsson | We are fine with changing FG 28-3 to “Full-duplex FDD operation for RedCap UE” assuming that “Half-duplex FDD operation type A in FDD bands” is included as a component of FG 28-1.If FG 28-1 does not include “Half-duplex FDD operation type A in FDD bands” as a component, then we prefer to continue the discussion regarding FG 28-3 until a satisfactory solution has been found. |
| Qualcomm | We think FG 28-3 should be kept. In our view, both FD-FDD and Type-A HD-FDD can be optionally supported by R17 RedCap UE. Specifically, on paired spectrum of FR1, a RedCap UE can support:* Type-A HD-FDD only
* FD-FDD only
* both FD-FDD and Type-A HD-FDD
 |
| Intel | We prefer to keep FG 28-3 as currently described. In our interpretation, it does not violate the RAN2 guidance on “incapability” indication. FG 28-3 is not just indicating an incapability of supporting FD-FDD but can be interpreted to indicate capability of supporting Type A HD-FDD operations and the associated UE behavior, instead of FD-FDD. Thus, an “alternate capability” as against an “incapability”.  |
| vivo | Agree with the comments by Intel above. 28-3 has been stable in the current table (no yellow highlight about its definition), better not reopen the discussion.  |
| ZTE, Sanechips | Current FG 28-3 is clear and it is not clear to us why should we define a FG to to support FDD, i.e., **Full ~~Half~~-duplex FDD operation ~~type A~~ for RedCap UE** |
| Samsung | Do not support the changeRAN 1 defined additional behavior for HD-FDD in the spec. therefore, for the UE doesn’t not support HD-FDD, UE doesn’t need to support related procedures. If changed to FD-FDD and make it as optional, does this imply that HD-FDD has to be supported by Redcap by default?  |
| DOCOMO | We prefer to keep current FG 28-3. We don’t think HD-FDD is incapability, as UE has to support HD-FDD specific UE behavior. |
| FUTUREWEI | Similar comments as Intel |
| Nokia, NSB | We agree with DOCOMO that 28-3 is not an incapability. If modified, then the Half-duplex operation would still need to be captured somewhere else. |
| FL2 | Summary of companies’ view* + Should be revised: [Ericsson]
	+ Should be kept: [Ericsson], Qualcomm, Intel, vivo, ZTE, Sanechips, DOCOMO, FUTUREWEI, Nokia, NSB
		- Not incapability but alternative capability

Given that most of companies prefer to keep current FG 28-3, no additional proposal is made for now and this discussion is closed. |

**Medium priority question 4-2:**

* **Companies are encouraged to provide views on whether the type of FG 28-3 should be per band or per UE**
	+ Per band: Ericsson, vivo, Guangdong Genius, Spreadtrum, DOCOMO, Qualcomm
	+ Per UE: Huawei, HiSilicon, Nokia, NSB, OPPO, Xiaomi, Samsung
		- FDD/TDD differentiation:
			* Necessary:
			* Not necessary: Huawei, HiSilicon, Nokia, NSB, Samsung (FDD only)
		- FR1/FR2 differentiation:
			* Necessary: Nokia, NSB
			* Not necessary: Huawei, HiSilicon, Samsung (FR1 only)

|  |  |
| --- | --- |
| Company | Comment |
| Nokia, NSB | * + Per UE
	+ FR1/2 differentiation
	+ No need for xDD differentiation
 |
| vivo | Per band, different FDD bands may have different duplex distance, therefore the cost/complexity due to the duplexer would be different. Given it is per band, no need for FDD/TDD or FR1/FR2 differentiation.  |
|  |  |

**Low priority question 4-3:**

* **Companies are encouraged to provide views on whether/how to revise any other contents in FG 28-3 which do not have capability signaling impacts**

|  |  |
| --- | --- |
| Company | Comment |
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|  |  |
|  |  |

# **28-5: UL 256QAM support for RedCap UE**

In [1], FG 28-5 is captured as below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between Ues (Sidelink WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
|  28. NR\_redcap | 28-5 | UL 256QAM support for RedCap UE | 1. Support of 256QAM for PUSCH for RedCap UE2. Support of 256QAM MCS table (Table 5.1.3.1-2 in TS 38.214) for PUSCH for RedCap UE | 28-1 | Yes |  | Impact on UE complexity and UL link performance at high SNR | Per band | No | No |  | For RedCap UEs, the 256QAM MCS table for PUSCH is only supported if the UE supports 256QAM for PUSCH. | Optional with capability signaling |

Following feedbacks are provided in contributions for the RAN1#107-e meeting.

|  |  |  |  |
| --- | --- | --- | --- |
| [2] | Ericsson | RAN1 has made the following agreements related to DL/UL modulation support:

|  |
| --- |
| Agreements:* For a RedCap UE, 64QAM MCS tables (Table 5.1.3.1-1 in TS 38.214 for DL and UL OFDM and Table 6.1.4.1-1 in TS 38.214 for UL w/ transform precoding respectively) are the “default” ones and are mandatory.
* The following is optionally supported by RedCap UEs:
	+ 256QAM MCS tables (Table 5.1.3.1-2 in TS 38.214 for DL and UL OFDM)
	+ 64QAM low SE MCS tables (Table 5.1.3.1-3 in TS 38.214 for DL and UL OFDM and Table 6.1.4.1-2 in TS 38.214 for UL w/ transform precoding respectively)

Agreements:* For a RedCap UE, “CQI table 1” (Table 5.2.2.1-2 in TS 38.214), that corresponds to MCS Table 5.1.3.1-1 in TS 38.214, is mandatory.
* The following is optionally supported by a RedCap UE:
	+ “CQI table 2” (Table 5.2.2.1-3 in TS 38.214) that corresponds to MCS Table 5.1.3.1-2 in TS 38.214 (256QAM MCS table)
	+ “CQI table 3” (Table 5.2.2.1-4 in TS 38.214) that corresponds to MCS Table 5.1.3.1-3 in TS 38.214 (64QAM low SE MCS table)

Agreements:* Both 256QAM MCS table for PDSCH and “CQI table 2” (Table 5.2.2.1-3 in TS 38.214) are supported by a RedCap UE indicating support of 256QAM for PDSCH.

Agreements:* For a RedCap UE, support of 64QAM low SE MCS table for PDSCH and support of “CQI table 3” (Table 5.2.2.1-4 in TS 38.214) are not coupled and capability of each can be reported independent of the other.

Agreements:* For a RedCap UE, support of 64QAM low SE MCS table for PDSCH (Table 5.1.3.1-3 in TS 38.214) and support of 64QAM low SE MCS tables for PUSCH (Table 5.1.3.1-3 in TS 38.214 for UL OFDM and Table 6.1.4.1-2 in TS 38.214 for UL w/ transform precoding respectively) are not coupled and capability of each can be reported independent of the other.
 |

The FGs related to DL/UL modulation support (FG 28-4 for DL and FG 28-5 for UL) that were present in the version discussed in [8] were intended to capture the above agreements. Many companies expressed that a preference to remove both FG 28-4 (which was removed) and FG 28-5 (which is still there). If these FGs are not present, how to capture the above agreements may require some further discussion.1. Discuss how to capture RedCap RAN1 agreements related to DL/UL modulation support.
 |
| [4] | FUTUREWEI | We have four observations with the revised formulation.***Observation 1.***1. ***FG 28-1 must include a basic feature for a reduced number of Rx branches***
2. ***FG 28-2 must be removed as indicated by RAN2***
3. ***FG 28-5 must be removed since UL 256QAM is not in the WID***
4. ***Capture Early Indication functionality***

FG 28-5FG 28-5 “UL 256QAM support for RedCap UE” must be removed as it is not an objective in the WID [5]. In the WID,* + *Support of 256QAM in DL is optional (instead of mandatory) for an FR1 RedCap UE.*
	+ *No other relaxations of maximum modulation order are specified for a RedCap UE.*

It is clear UL 256QAM is not discussed for RedCap UEs.In addition, UL 256QAM is already captured as optional FG 1-5 (RF and RRM features). There is no need to introduce this FG especially since the WID [5] states* *The existing UE capability framework is used; changes to capability signalling are specified only if necessary.*
 |
| [5] | vivo, Guangdong Genius | For FG 28-5, we think this FG is not needed for RedCap, since the capability of pusch-256QAM in TS 38.306 is already an optional capability and reported per band. RedCap UE can re-use this capability. It is noted that the legacy UE is mandated to support 256QAM MCS table even if it does not support 256QAM on uplink. To reflect the agreement made in RAN1#105-e meeting that for RedCap UEs, the 256QAM MCS table for PUSCH is only supported if the UE supports 256QAM for PUSCH. We would be fine to add a note in FG 1-5 (256QAM for PUSCH) to clarify that “For RedCap UEs, the 256QAM MCS table for PUSCH is only supported if the UE supports 256QAM for PUSCH”. **Proposal 10: Remove the FG 28-5 of UL 256QAM support for RedCap UE.** * **The optional capability of pusch-256QAM can be reused for RedCap UE.**
* **Add a note in FG 1-5 (256QAM for PUSCH) that “For RedCap UEs, the 256QAM MCS table for PUSCH is only supported if the UE supports 256QAM for PUSCH”**
 |
| [9] | OPPO | The existing the capability of pdsch-256QAM-FR1 is mandatory with capability signaling and applied to FR1 only. We think that mandatory with capability signaling can be reinterpreted by RedCap UE. If the 28-1 is indicated, then we can look pdsch-256QAM-FR1 as no mandatory.For other cases of 256QAM indication, they are optional. Thus, we prefer to not introduce new UE capability for 256QAM for both UL/DL and all FRs. ***Proposal 4: For FG 28-4 and 5, do not introduce new UE features.*** |
| [10] | Intel Corporation | For some of the FGs #28-x identified so far, the FG type can be confirmed as “per band”, with exception of FG #28-1 which should be per UE. For FG #28 -1, the type should be “per UE” since the overall cost/complexity reduction benefit for a UE that may behave as non-RedCap UE in some bands while as a RedCap UE in some others is rather limited. More importantly, given the single carrier operation for RedCap UEs, what matters is if the UE reports itself a RedCap UE for the carrier in the band in which the UE may be currently camping on. Thus, a “per UE” capability indication for FG 28-1 is sufficient.**Proposal 1:*** *Confirm the type for FG 28-1 as “per UE”.*
* *Confirm the type for the following Rel-17 FGs for RedCap as “per band”:*
	+ *FGs #28-2, 28-3, 28-5 (if introduced).*

Next, on FDD/TDD differentiation, while FG #28-3 is applicable to FDD spectra and FR1 bands only, there is no need for FDD/TDD differentiation for FG #28-1 (for similar reasons why “per band” signaling is not necessary for FG #28-1) or for FG #28-2 if the latter is associated with “per band” type. FG #25-5, if introduced, can follow FG #28-2 in obviating need for TDD/FDD differentiation. **Proposal 3:*** *FDD/TDD differentiation is not necessary for FGs 28-1, 28-2, and 28-5 (if introduced).*
* *FG 28-3 is only applicable in FDD and FR1 bands.*

Regarding FG 28-5 related to support of 256QAM in the UL, as for FG 28-4, FG 28-5 can be removed and a corresponding note for RedCap UEs can be added to RAN4 FG 1-5 on support of 256QAM for PUSCH in the UL, indicating the following:* For RedCap UEs, support of 256QAM for PUSCH is optional in both FR1 and FR2
* For RedCap UEs, the 256QAM MCS table for PUSCH is only supported if the UE supports 256QAM for PUSCH.

**Proposal 4:*** *Remove FG 28-5.*
* *Add the following notes to RAN4 FG 1-5 “256QAM for PUSCH”*
	+ *For RedCap UEs, support of 256QAM for PUSCH is optional in both FR1 and FR2*
	+ *For RedCap UEs, the 256QAM MCS table for PUSCH is only supported if the UE supports 256QAM for PUSCH.*
 |
| [11] | Xiaomi | Since the support of UL 256 QAM is also optional in NR R15 and there is no change for RedCap. Therefore, there is no need to introduce a new FG dedicated for RedCap. **Proposal 4: Remove FG 28-5** |
| [13] | Samsung | FG 28-4 DL 256QAM support for RedCap UE was agreed to be removed and combined into FG1-4. We think same principle can be reused for UL 256QAM. Moever, there is no change compared with NR UE. Therefore, we suggest to remove this feature 28-5 from the RedCap feature list.  ***Proposal #4: Remove Feature 28-5 from RedCap Feature list with the assumption that this capability can be shared with NR UE.***  |
| [14] | Apple | Similarly, support of 256QAM for PUSCH is an optional feature for Rel-15 eMBB UEs, which is indicated by FG 1-5 (*pusch-256QAM*). The FG 1-5 can be fully reused for Redcap without differentiating from legacy UEs on this aspect. One concern has been raised in RAN1 106 bis e-meeting is how the specifications captures the earlier agreement that (for both FR1 and FR2) that 256QAM MCS table for PUSCH is only supported if the UE supports 256QAM for PUSCH. This can be simply captured as one note for Redcap UE in FG 1-5. Regarding the feature type, FG 1-5 is defined as ‘per band’ in legacy and desirable for Redcap UE as well. **Proposal 5: Remove FG 28-5 in [1] and add a note for the FG 1-5 that for Redcap UE,** the **256QAM MCS table for PUSCH is only supported if the UE supports 256QAM for PUSCH.**  |
| [16] | NTT DOCOMO, INC. | * FG 28-5: UL 256QAM support for RedCap UE
	+ Currently DL 256QAM is supported/reported as optional with capability signalling for both FR1 and FR2 using *pusch-256QAM* per band and hence, it can be used for RedCap UEs as well. In that sense, we don’t see any motivation to introduce FG 28-5 in addition to *pusch-256QAM*.
	+ FG 28-5 should be removed
	+ Add a note in FG 1-5 (256QAM for PUSCH) that “For RedCap UEs, the 256QAM MCS table for PUSCH is only supported if the UE supports 256QAM for PUSCH”
 |
| [18] | MediaTek Inc. | **FG28-5:** the support of 256QAM for PUSCH is already optional in NR R15, and there is no need to introduce new feature to report it. R15 FG 1-5 can be used by RedCap UEs to report the support of 256QAM for PUSCH. |

## **Discussion**

**[FL1] High priority question 5-1:**

* **FG 28-5 is removed**
* **Add a note in FG 1-5 (256QAM for PUSCH) that “For RedCap UEs, the 256QAM MCS table for PUSCH is only supported if the UE supports 256QAM for PUSCH”**

|  |  |
| --- | --- |
| Company | Comment |
| Ericsson | We are fine with removing FG 28-5 assuming that “Up to 64QAM for PDSCH” is included as a component of FG 28-1 AND the following RedCap RAN1 agreements regarding MCS and CQI tables are captured properly somehow.

|  |
| --- |
| Agreements:* For a RedCap UE, 64QAM MCS tables (Table 5.1.3.1-1 in TS 38.214 for DL and UL OFDM and Table 6.1.4.1-1 in TS 38.214 for UL w/ transform precoding respectively) are the “default” ones and are mandatory.
* The following is optionally supported by RedCap UEs:
	+ 256QAM MCS tables (Table 5.1.3.1-2 in TS 38.214 for DL and UL OFDM)
	+ 64QAM low SE MCS tables (Table 5.1.3.1-3 in TS 38.214 for DL and UL OFDM and Table 6.1.4.1-2 in TS 38.214 for UL w/ transform precoding respectively)

Agreements:* For a RedCap UE, “CQI table 1” (Table 5.2.2.1-2 in TS 38.214), that corresponds to MCS Table 5.1.3.1-1 in TS 38.214, is mandatory.
* The following is optionally supported by a RedCap UE:
	+ “CQI table 2” (Table 5.2.2.1-3 in TS 38.214) that corresponds to MCS Table 5.1.3.1-2 in TS 38.214 (256QAM MCS table)
	+ “CQI table 3” (Table 5.2.2.1-4 in TS 38.214) that corresponds to MCS Table 5.1.3.1-3 in TS 38.214 (64QAM low SE MCS table)

Agreements:* Both 256QAM MCS table for PDSCH and “CQI table 2” (Table 5.2.2.1-3 in TS 38.214) are supported by a RedCap UE indicating support of 256QAM for PDSCH.

Agreements:* For a RedCap UE, support of 64QAM low SE MCS table for PDSCH and support of “CQI table 3” (Table 5.2.2.1-4 in TS 38.214) are not coupled and capability of each can be reported independent of the other.

Agreements:* For a RedCap UE, support of 64QAM low SE MCS table for PDSCH (Table 5.1.3.1-3 in TS 38.214) and support of 64QAM low SE MCS tables for PUSCH (Table 5.1.3.1-3 in TS 38.214 for UL OFDM and Table 6.1.4.1-2 in TS 38.214 for UL w/ transform precoding respectively) are not coupled and capability of each can be reported independent of the other.
 |

If FG 28-1 does not include “Up to 64QAM for PDSCH” as a component OR it is unclear whether the above RedCap RAN1 agreements regarding MCS and CQI tables are captured properly somehow, then we prefer to continue the discussion regarding FG 28-5 until a satisfactory solution has been found. |
| Qualcomm | We don’t think R17 RedCap UE needs to support 256QAM for PUSCH. As a result, the 256QAM MCS table for PUSCH should not be supported.In the UE complexity reduction study for R17 RedCap SI, 256 QAM for PUSCH has been ruled out. None of the use cases listed in the R17 WID requires 256 QAM for PUSCH. |
| Intel | Support.We are also fine to add “Up to 64QAM for PDSCH” as a component of FG 28-1 as suggested by Ericsson.On the agreements on support of mandatory/optional MCS/CQI tables cited by Ericsson, in our understanding these are consistent with current specifications (for Rel-15). Further, the mandatory requirements for CQI/MCS tables need not be spelled out following the principle that features in core specs that are not identified in UE features explicitly are mandatory w/o capability signaling.  |
| vivo | Fine with the proposal.  |
| ZTE, Sanechips | Support to remove the FG 28-5.Regarding the RF and RRM features 1-5, whether to support 256QAM MCS table for PUSCH can be discussed in [107-e-R17-UE-features-REDCAP-02]. |
| Samsung  | Support |
| DOCOMO | Support |
| FUTUREWEI | This FG should never have been included in the initial list.It should be up to the proponent to convince the group that special handling is required for 256QAM UL and include something; instead, now something is included and then we all have to agree to the proponent's terms to remove it. |
| FL2 | Summary of companies’ view* + Remove FG 28-5
		- [Ericsson], Qualcomm, Intel, vivo, ZTE, Sanechips, Samsung, DOCOMO, FUTUREWEI
	+ Add a note in FG 1-5
		- Intel, vivo, Samsung, DOCOMO
	+ RAN1 agreements regarding MCS and CQI tables should be captured properly somehow
		- Necessary: Ericsson
		- Not necessary: Intel, FUTUREWEI
			* these are consistent with current specifications (for Rel-15).
		- Can be discussed in [107-e-R17-UE-features-REDCAP-02]
			* ZTE, Sanechips

Given that majority companies are fine to remove FG 28-5 while companies have different view on whether/how to capture RAN1 agreement regarding MCS and CQI tables, moderator thinks adding a note in FG 1-5 is a good middle ground among companies. Therefore, the same proposal is set for further discussion. **[FL2] High priority proposal 5-1:*** **FG 28-5 is removed**
* **Add a note in FG 1-5 (256QAM for PUSCH) that “For RedCap UEs, the 256QAM MCS table for PUSCH is only supported if the UE supports 256QAM for PUSCH”**
 |
| Ericsson | Ok |
| HW, HiSi | Agree |
| DOCOMO | We support the proposal |
| vivo | Y |
| Qualcomm | We can live with FL2 proposal for the sake of progress |
| ZTE, Sanechips | Agree.  |
| Xiaomi | We are OK with FL’s proposal  |

# **Other FGs**

This section discusses other FGs which are not included in [1].

Following feedbacks are provided in contributions for the RAN1#107-e meeting.

|  |  |  |
| --- | --- | --- |
| [4] | FUTUREWEI | We have four observations with the revised formulation.***Observation 1.***1. ***FG 28-1 must include a basic feature for a reduced number of Rx branches***
2. ***FG 28-2 must be removed as indicated by RAN2***
3. ***FG 28-5 must be removed since UL 256QAM is not in the WID***
4. ***Capture Early Indication functionality***

Early indicationOne such missing basic functionality from [3] is the Early Indication functionality. From [5], * *Specify functionality that will enable RedCap UEs to be explicitly identifiable to networks through an early indication in Msg1 and/or Msg3, and Msg A if supported, including the ability for the early indication to be configurable by the network. [RAN2, RAN1]*

Though all UEs are also identifiable as RedCap through the normal capability exchange, it is beneficial (and the intent of the WID) for all UEs to support early indication and be able to use it. This topic was discussed in [1], but no progress was made. While there may be a debate which working group should capture early indication functionality, RAN2 can modify the capability signaling as they see fit. There are several ways to capture early indication: as a mandatory feature or as part of the basic feature group for RedCap UE. We can accept either. |
| [5] | vivo, Guangdong Genius | * + Early indication for RedCap UE

RAN1 agreed to support the early indication of RedCap UE in Msg1 for 4-step RACH and 2-step RACH. In addition, RAN2 agreed to support early indication of RedCap UE by Msg3 based on dedicated LCID (if SA3 confirms there is no problem) [5]. Therefore, following example FGs related to early indication for RedCap UE should be added:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 28. NR\_redcap | 28-u | Early indication of RedCap UE in Msg.1 for 4-step RACH  | 1. The early indication in Msg1 for 4-step RACH in shared initial UL BWP can be configured to be enabled/disabled via SIB
2. The early indication PRACH resources including RO and preamble determination in shared initial UL BWP
 | 28-1 | Yes |  | Impact on UE performance  | [Per band] | No | [No] |  | Shared initial UL BWP is for the initial UL BWP sahred between RedCap and non-RedCap  | Optional with capability signalling |
| 28. NR\_redcap | 28-ua | Early indication of RedCap UE in Msg.A for 2-step RACH | 1. The early indication in Msg1 for 2-step RACH in shared initial UL BWP can be configured to be enabled/disabled via SIB
2. The early indication Msg.A resource (FFS Msg.A PRACH or Msg.A PUSCH) determination in shared initial UL BWP
 | 9-1, 28-1 | Yes |  | Impact on UE performance | [Per band] | No | [No] |  | Shared initial UL BWP is for the initial UL BWP sahred between RedCap and non-RedCapFG 9-1 is Basic channel structure and procedure of 2-step RACH | Optional with capability signalling |
| 28. NR\_redcap | 28-v | Early indication of RedCap UE in Msg.3 | 1. The early indication of RedCap UE in Msg3 based on dedicated LCID
 | 28-1 | Yes |  | Impact on UE performance | [Per band] | No | [No] |  |  | Optional with capability signalling |

From our understanding, if the separate initial UL BWP is configured for RedCap UEs, the PRACH transmission is the separate initial UL BWP naturally indicate the RedCap UE. Therefore, the FG of early indication of RedCap UE in Msg.1 for 4-step RACH is needed only when the initial UL BWP is shared between the RedCap and non-RedCap UEs. Since separate initial UL BWP is basic RedCap UE features, there is already a way to early indicate the RedCap UE. To reduce the UE implementation complexity and testing efforts for duplicated function, the FG28-u or FG28-v of early indication in Msg.1 or in Msg.3 should be optional UE FG. **Proposal 6: Adding following optional FGs related to the early indication for RedCap UE.*** **FG28-u: Early indication of RedCap UE in Msg.1 for 4-step RACH**
* **FG28-ua: Early indication of RedCap UE in Msg.A for 2-step RACH**
* **FG28-v: Early indication of RedCap UE in Msg.3**
 |
| [6] | ZTE, Sanechips | Also for RedCap UE, the early identification is kind of mandatory feature since it can be configured by the gNB via SIB. However, for the optional 2-step RACH, msgA identification is also an optional feature. Therefore, we have the following proposal:***Proposal 17: For RedCap UE,*** * ***msg1 identification is mandatory feature for RedCap UE***
* ***msgA identification is optional feature***
 |
| [10] | Intel Corporation | For FG 28-1, support of early identification during Msg1 transmission can be captured as a component. Further, assuming 2-step RACH is optionally supported by RedCap and that RedCap early identification during MsgA preamble transmission is introduced, such a component may be captured as a component relevant only to RedCap UEs for existing 2-step RACH feature. Alternatively, a separate feature FG 28-y may be introduced that is mandatory for RedCap UE (i.e., supporting FG 28-1) supporting 2-step RACH.**Proposal 2:*** *Capture the following as a component for FG 28-1:*
	+ *“For 4-step RACH, support of early identification of RedCap UE during Msg1 transmission”*
* *FFS: Details on capturing support of RedCap early identification during MsgA preamble transmission for 2-step RACH.*

On Rel-17 features, and possible optional support or non-applicability of some of them for RedCap UEs, we share our views at a high-level, while the details of the other Rel-17 features are being developed in RAN1.* UE power saving enh
	+ Can be optionally supported
* Coverage enh
	+ Can be optionally supported
* SDT
	+ Can be optionally supported
* MBS
	+ Can be optionally supported
* IIoT/URLLC further enhancements
	+ Can be optionally supported
* NTN
	+ Can be optionally supported
* feMIMO
	+ At least some Multi-TRP-related features related to high reliability may be optionally supported
* Above-52GHz
	+ Not supported by RedCap UEs
* ePositioning
	+ Not supported by RedCap UEs
* eIAB
	+ Not supported by RedCap UEs
* SL/V2X enh
	+ Not supported by RedCap UEs
* DSS enh
	+ Not supported by RedCap UEs
* NR DC/CA further enhancements
	+ Not supported by RedCap UEs
* DL 1024QAM
	+ Not supported by RedCap UEs

**Proposal 9:*** *Initial views on applicability of some of the Rel-17 features for RedCap UEs are as follows:*
* ***UE power saving enh***
	+ *Can be optionally supported*
* ***Coverage enh***
	+ *Can be optionally supported*
* ***SDT***
	+ *Can be optionally supported*
* ***MBS***
	+ *Can be optionally supported*
* ***IIoT/URLLC further enhancements***
	+ *Can be optionally supported*
* ***NTN***
	+ *Can be optionally supported*
* ***feMIMO***
	+ *At least some Multi-TRP-related features related to high reliability may be optionally supported*
* ***Above-52GHz***
	+ *Not supported by RedCap UEs*
* ***ePositioning***
	+ *Not supported by RedCap UEs*
* ***eIAB***
	+ *Not supported by RedCap UEs*
* ***SL/V2X enh***
	+ *Not supported by RedCap UEs*
* ***DSS enh***
	+ *Not supported by RedCap UEs*
* ***NR DC/CA further enhancements***
	+ *Not supported by RedCap UEs*
* ***DL 1024QAM***
	+ *Not supported by RedCap UEs*
 |
| [12] | CMCC | * Early identification of RedCap UEs

According to related agreements made in RAN1#106e, RedCap UEs should support early identification at least in Msg1, and RAN2 has also agreed to support early indication of RedCap UEs in Msg3. So early identification related function should also be included in FG28-1 as basic UE feature.Agreements: [38.331]Confirm the following working assumption with the modifications in red:* For 4-step RACH, support the early indication of RedCap UEs at least in Msg1.
	+ The early indication in Msg1 can be configured to be enabled/disabled via SIB
		- ~~FFS how to support enable/disable the early indication~~
	+ ~~FFS details e.g.:~~ From RAN1 perspective, the following methods can be used for early indication both for shared initial UL BWP and separate initial UL BWP (if supported)
		- separate PRACH resource
		- PRACH preamble partitioning
		- ~~FFS: whether/how to address RA-RNTI overlapping issue~~
	+ ~~FFS the possibility of supporting Msg3 for the early indication~~

Whether/how to support early indication of RedCap UEs in Msg3 in Rel-17 is up to RAN2.To realize early identification in Msg1, RedCap UE should be able to determine its separate PRACH resource or PRACH preambles, so as to initiate random access on shared initial UL BWP or separate initial UL BWP. Taking 2-step RACH as reference, “2. msgA PRACH resource and format determination” is included in its FG9-1, may be it can include “RedCap dedicated PRACH resource or PRACH preamble determination” in FG28-1. It also need to receive RACH related downlink channels in separated initial DL BWP if configured.**Proposal 3: Add the following components into the fourth column of FG28-1,*** **RedCap dedicated PRACH resource or PRACH preamble determination;**
* **Receiving RACH related downlink channels in separated initial DL BWP if RACH related CSS/CORESET is configured**
 |
| [14] | Apple | One FFS aspect for FG 28-1 is whether to add other UE features. In our view, there is no need to merge FG 28-2 and FG 28-3 into basic group FG 28-1 to provide desirable implementation flexibility for Redcap UEs to fulfil different peak data rate use cases and market demand. In addition, it should be noted that support of 1 Rx cannot be basic feature required for Redcap as UE implemented with 2 Rx does not necessarily meet the 1 Rx requirement. In addition to reduced BW, other basic FGs (e.g., support early indication of Redcap UE, NCD-SSB in a separate BWP etc.) can be merged into FG 28-1. Regarding the type of FG 28-1, we prefer to define it as ‘per Band’, which offers important flexibility for UE in terms of Redcap capability report considering the testing differences in licensed, unlicensed, NTN bands as well as FR1/FR2 bands. **Proposal 1**: **Consider adding the following basic FGs into FG 28-1:** * *Early indication of Redcap UE by separate PRACH resource or PRACH preamble or Msg3 in 4-step RACH procedure in a shared initial UL BWP (if not included in RAN2 FG list)*
* *The early indication in Msg1 can be configured to be enabled/disabled via SIB*
* *NCD-SSB in a sperate initial DL BWP that does not include CD-SSB.*
 |
| [15] | NEC | Support of early indication is considered as an essential feature for a RedCap UE so that the network can identify it for access control, appropriate handling, etc.**Proposal:*** Early indication can be included in FG28-1 (if FG 28-1 does not belong to UE RF feature)

A RedCap may optionally support 2-step RACH. However, it would not be obvious whether a RedCap UE supporting 2-step RACH always supports early indication by 2-step RACH. Early indication by 2-step RACH could be optional for a RedCap UE supporting 2-step RACH.**Proposal:*** Whether early indication by 2-step RACH is optional for a RedCap UE supporting 2-step RACH can be discussed
 |
| [17] | Qualcomm Incorporated | Based on the WID [1], a R17 RedCap UE is expected to support UL coverage enhancement solutions and power saving solutions specified in NR R17 by default.***Proposal 9*: *R17 UE features introduced in UL coverage enhancement WI and Power Saving WI can be supported by R17 RedCap UE as optional capabilities.***In addition to power saving and coverage enhancement, 17 UE features related to NR positioning, NR small data transfer and NR multicast/broadcast can be optionally supported by RedCap UE.***Proposal 10*: *R17 UE features related to NR positioning, NR small data transfer and NR multicast/broadcast can be optionally supported by R17 RedCap UE.*** |

## **Discussion**

**[FL1] High priority question 6-1:**

* **Companies are encouraged to provide views on whether/how to add features for early indication of RedCap UE, e.g.,**
	+ **FG or component in FG 28-1 for early indication of RedCap UE in Msg.1 for 4-step RACH**
	+ **FG or component in FG 28-1 for early indication of RedCap UE in Msg.A for 2-step RACH**
	+ **FG or component in FG 28-1 for early indication of RedCap UE in Msg.3**

|  |  |
| --- | --- |
| Company | Comment |
| Ericsson | We are fine with listing support for the early indications as components but not as separate FGs, since it be seen as a fundamental part of the support for the RedCap UE complexity reduction techniques. |
| Qualcomm | Since a RedCap UE needs to support SIB-configured separate initial UL BWP (due to BW reduction and/or a change of BWP center frequency in TDD), it should support early indication of RedCap UE type in msg1 or msgA PRACH (if 2-step RACH is supported). Therefore, we support to add the features associated with early indication of RedCap UE type, due to the connection with RedCap-specific initial UL BWP configuration |
| Intel | * We support to adding a component to capture support of early identification in Msg1 for 4-step RACH.
* For 2-step RACH, if added, it should be conditioned on UE’s support of 2-step RACH.
* For early identification via Msg3, it may be left up to RAN2 as a RAN2 feature.
 |
| vivo | We prefer to list the 3 early indication features as 3 separate new FGs.  |
| ZTE, Sanechips | At least from RAN1 perspective, the first subbullet and second subbullet can be supported. Moreover, they can be viewed as the component of FG28-1 or a basic feature group for RedCap UE, since they may be used before UE capability report. |
| NEC | Share view with Intel. |
| Samsung | This should be discussed in RAN 2.  |
| DOCOMO | We still think they should be discussed in RAN2 since they are RAN2-led items. |
| FUTUREWEI | Similar view as Intel |
| Nokia, NSB | Support |
| FL2 | Summary of companies’ view* + early indication of RedCap UE in Msg.1 for 4-step RACH
		- Support: Ericsson, Qualcomm
			* Add as an FG: vivo
			* Add as a component in FG 28-1: Ericsson, Intel, ZTE, Sanechips, NEC, FUTUREWEI
				+ fundamental part of the support for the RedCap UE complexity reduction techniques
				+ may be used before UE capability report
		- Up to RAN2: Samsung, DOCOMO
	+ early indication of RedCap UE in Msg.A for 2-step RACH
		- Support: Intel (conditioned on support of 2-step RACH), NEC (conditioned on support of 2-step RACH), FUTUREWEI (conditioned on support of 2-step RACH)
			* Add as an FG: vivo
			* Add as a component in FG 28-1: Ericsson, ZTE, Sanechips
				+ fundamental part of the support for the RedCap UE complexity reduction techniques
				+ may be used before UE capability report
		- Up to RAN2: Samsung, DOCOMO
	+ early indication of RedCap UE in Msg.3
		- Support: Ericsson, Qualcomm
			* Add as an FG: vivo
			* Add as a component in FG 28-1: Ericsson
				+ fundamental part of the support for the RedCap UE complexity reduction techniques
		- Up to RAN2: Intel, NEC, Samsung, DOCOMO, FUTUREWEI

Based on the above, following proposal is made**[FL2] High priority proposal 6-1:*** **For early indication of RedCap UE,**
	+ **The capability of early indication of RedCap UE in Msg.1 for 4-step RACH is added in RAN1 UE feature list**
		- **FFS whether to add as a separate FG or component in FG 28-1**
	+ **The capability of early indication of RedCap UE in Msg.A for 2-step RACH is added in RAN1 UE feature list**
		- **It is conditioned on support of 2-step RACH**
		- **FFS whether to add as a separate FG or component in FG 28-1**
	+ **Whether/how to add the capability of early indication of RedCap UE Msg.3 for 4-step RACH is up to RAN2**
 |
| Ericsson | Actually, we prefer to NOT include early indication as a capability – not as a component and definitely not as an FG. If the early indication becomes anything else than fully mandatory (without capability signaling), then the early indication essentially becomes a useless feature, which was probably not the intention by many companies when the WID was drafted and approved.The early indication is implicitly given by simply using the configured PRACH configuration. There are probably other aspects of the reduced UE bandwidth feature that are more worthy of being listed as a separate capability (not that we see the need for that either).So, we prefer to not include early indication as a capability, although we can live with listing it as a component of FG 28-1 (but NOT as a separate FG). |
| HW, HiSi | We are fine with the FL proposal however we think it can go step further to add Msg-1 based EI into FG 28-1 since this actually does not require any additional UE capability - it is implicitly achieved by gNB configuring different RACH resources and a RedCap UE will anyway support that. |
| DOCOMO | We can live with the proposal. For Msg1/A indication, they should be added as components in FG 28-1. |
| vivo | Early indication by MSG.A cannot be included as a component of FG28-1, as its parent capability (2-STEP RACH) is a separate optional feature. Therefore, early indication by MSG.A can only be a separate FG, if considered. Regarding 4-step RACH, we do not support to split the discussion as MSG 1 in RAN1 and MSG3 in RAN2, we should discuss and decide which one of the two is the most desirable option from real deployment perspective and make it an component of FG 28-1 (meaning a basic feature for RedCap UEs), while leave the other option out from FG28-1 (i.e. as separate FG).  |
| Qualcomm | Support FL2 proposal. We are also fine to combine msg1-based early indication with FG 28-1. |
| ZTE, Sanechips | We support this proposal. Early indication of RedCap UE in Msg.1 for 4-step RACH should be mandatorily supported. Therefore, we are OK to set it as a component in FG 28-1. For early indication of RedCap UE in Msg.A for 2-step RACH, it is conditioned on support of 2-step RACH which is optional. Therefore, it is not appropriate to set it as a component in 28-1. |
| Xiaomi | We support FL’s proposal. And we are OK with to include Msg.1-based early indication in 4-step in FG 28-1. For Msg.A-based early indication, it can be set as an separate FG.  |

**Medium priority question 6-2:**

* **Companies are encouraged to provide views on which Rel-17 UE features (FGs 23-x to 36-x) are not applicable to RedCap UEs**

|  |  |
| --- | --- |
| Company | Comment |
|  |  |
|  |  |
|  |  |

# **Conclusions**

TBD

# **References**

[1] R1-2110587 Updated RAN1 UE features list for Rel-17 NR after RAN1 #106bis-e Moderators (AT&T, NTT DOCOMO, INC.)

[2] R1-2110773 UE features for RedCap Ericsson

[3] R1-2110803 Rel-17 UE features for RedCap Huawei, HiSilicon

[4] R1-2110893 Further discussion on UE features for REDCAP FUTUREWEI

[5] R1-2111054 Discussion on UE feature for NR REDCAP vivo, Guangdong Genius

[6] R1-2111072 Discussion on RedCap UE features ZTE, Sanechips

[7] R1-2111119 UE features for RedCap Spreadtrum Communications

[8] R1-2111157 On UE features for REDCAP Nokia, Nokia Shanghai Bell

[9] R1-2111333 Rel-17 RedCap UE features OPPO

[10] R1-2111530 On UE features for RedCap Intel Corporation

[11] R1-2111562 Discussion on Rel-17 UE features on RedCap Xiaomi

[12] R1-2111636 Discussion on UE features for RedCap CMCC

[13] R1-2111774 UE feature for RedCap Samsung

[14] R1-2111910 UE features for RedCap Apple

[15] R1-2111959 Discussion on UE feature of RedCap NEC

[16] R1-2112136 Discussion on UE features for RedCap NTT DOCOMO, INC.

[17] R1-2112251 UE features for RedCap Qualcomm Incorporated

[18] R1-2112289 Views on UE features for RedCap MediaTek Inc.