**3GPP TSG RAN WG1 #110 R1-2207705**

**Toulouse, France, August 22nd – 26th, 2022**

**Agenda item:** 8.16.5

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

**Title:** Summary on UE features for NR RedCap

**Document for:** Discussion and Decision

# **Introduction**

This document summarizes contributions submitted to AI 8.16.5 regarding UE features for NR RedCap and captures company views based on the announcement in the following email thread.

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| [110-R17-UE\_features\_1] To be used for sharing updates on online/offline schedule, details on what is to be discussed in online/offline sessions, tdoc number of the moderator summary for online session, etc – Hiroki (DOCOMO)   * eIIoT & URLLC, RedCap, UE power saving, coverage enhancement, NB-IoT & eMTC, sidelink, MBS, 5G terrestrial broadcast, UL TX switching, SDT |

Based on the latest RAN1 UE features list in [1] and contributions in AI 8.16.5 discussing UE features for NR RedCap, the issues to be discussed are tagged and colour coded with High priority or Low priority based on potential RAN2 spec impact (including description update in TS38.306).

# **Discussion**

## **2.1 28-1: RedCap UE**

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

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| 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.  3. Early indication of RedCap UE in Msg.1 for 4-step RACH  4. Separate initial UL BWP for RedCap UEs  - It includes the configuration(s) needed for RedCap UE to perform random access  - Enabling/disabling of frequency hopping for common PUCCH resources  5. Separate initial DL BWP for RedCap UEs  - It includes CSS/CORESET for random access  - FFS: For separate initial DL BWP used for paging, CD-SSB is included  - For separate initial DL BWP only used for RACH, SSB may or may not be included  6. 1 UE-specific RRC configured DL BWP per carrier  7. 1 UE-specific RRC configured UL BWP per carrier  8. RRC reconfiguration of any parameters related to BWP  9. UE-specific RRC configured DL BWP with CD-SSB or NCD-SSB  10. NCD-SSB based measurements in RRC-configured DL BWP  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.  It is up to RAN2 whether/how to capture the capabilities for early indication of RedCap UE in Msg 3 and Msg A  A UE supporting this FG is not required to support FG 6-1 | Optional with capability signaling  RedCap UE must indicate this FG is supported |

Following views are provided in contributions for the RAN1#110 meeting.

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| [2] | Huawei, HiSilicon | For NR Rel-15/16 UE, the basic FG 3-1 for DL control channel is support of “one configured CORESET per BWP per cell in addition to CORESET0” as in TR38.822. So gNB can only configure one CORESET with *ControlResourceSetId* other than 0 in a BWP (initial/non-initial BWP), no matter if the BWP contains the bandwidth of CORESET0 or not. If RedCap UEs follow the same rule, only one CORESET can be used for both common and dedicated search spaces, when the BWP does not contain the bandwidth of CORESET0, which could significantly limit the flexibility of network scheduling, or even cause congestion problem compared with two separate CORESETs in legacy operation. Thus, we propose  ***Proposal 8-1: A RedCap UE should support one configured CORESET per BWP per cell in addition to CORESET0 if the BWP contains CORESET0, otherwise, support two configured CORESETs other than CORESET0 per BWP per cell, e.g. one common CORESET and one UE-specific CORESET.*** |
| [3] | ZTE | According to the WID [3] and agreement, UE capabilities related to CA, DC and wider max UE bandwidth are not applicable to RedCap UEs. However, it seems that whether to support the UE capabilities exceeding 1Tx/2Rx capability, were controversial in the discussion of UE feature agenda.  Given the Rel-17 RedCap WID description, the maximum UL peak data rate for wearables is 50Mbps. Obviously, support of more than 1Tx is not necessary, since the peak data rate can be up to 90Mbps for 64QAM and 1 layer with SCS=15KHz according to the calculation. More Tx antennas bring more complexity and cost, which is not aligned with the motivation of the WI. Moreover, for 1Rx RedCap UE, supporting more than 1 UL port seems to be impossible due to the physical circuit.  Additionally, according to the RAN4 discussion [4] as following, actually 2Tx is excluded:   |  | | --- | | **Issue 1-1: Power class and TX architecture in FR1**   * Proposals:   + Option 1: Agree below agreement from RAN4#101-bis-e   Issue 1-1-1: 1 PC3 UL TX architecture assumption   * WF   + For TX architecture of 23 dBm PA   Issue 1-1-2: PC2 UL TX architecture assumption   * WF   + 1 TX of 26 dBm PA in Rel-17 and 2 TX architecture is excluded in Rel-17   Issue 1-1-3: PC2 support for HD-FDD mode   * WF   + PC2 support based on operator request * Recommended WF   + Option 1   Discussion:  **Agreement: agree on Option 1.** |   Therefore, based on above, the FGs exceeding 1 Rx UE capability should not be supported, e.g., FG 2-13, 2-14, 2-16b . Therefore, we have the following proposal:  ***Proposal 5:*** *For RedCap UE, UE capabilities exceeding 1Tx capability is not supported.*  For those Rel-17 features, we also need to determine whether RedCap UE can support or not. At least eIAB and NR DC/CA further enhancements should not be supported according to the Rel-17 RedCap WID and agreement. Regarding above-52GHz, from our perspective, it is premature to support this feature, since some of the FGs actually exceeds the RedCap UE capability, e.g., SCS for DL control channel. For Rel-17 feMIMO, at least the FGs exceeding RedCap UE capability should be excluded, e.g., 23-1-1c, 23-1-1e, 23-1-1f, 23-1-1g, 23-8-3, 23-8-9, 23-9-3. As for the MBS, it seems be problematic to use separate initial DL BWP without SSB for RedCap UE. And this feature should be discussed with high priority.  ***Proposal 6:*** *For RedCap UE, we have the following proposals related to other Rel-17 features,*   * *eIAB and NR DC/CA further enhancements should be excluded.* * *The features for above-52GHz and feMIMO are not supported.* * *Discuss and decide with high priority whether MBS should be supported.* |
| [4] | vivo | * Issue#1: For component 5, there is one FFS   + 5. Separate initial DL BWP for RedCap UEes     - It includes CSS/CORESET for random access     - FFS: For separate initial DL BWP used for paging, CD-SSB is included     - For separate initial DL BWP only used for RACH, SSB may or may not be included * Issue#2: FFS whether to add any other basic features for RedCap UE   For the 1st issue, following agreements were made in RAN2#118-e meeting [2]:   |  | | --- | | 29. Clarify in the RRC field description that the paging search space is configured in an initial BWP only if that BWP includes the CD-SSB.  30. RAN2 confirms that if RedCap-specific initial DL BWP does not contain CD-SSB and CORESET#0, then this BWP will not be configured with a paging search space in any RRC state. In this case, the RedCap UE in RRC\_CONNECTED state is not required to read paging.  31. Reply to RAN1 and explain there is no need to support paging connected RedCap UEs in a RedCap-specific initial DL BWP which does not contain CD-SSB and CORESET#0. |   Based on above RAN2’s agreements, if the paging search space is included in the separate initial DL BWP, CD-SSB should be included. Therefore, the component 5 can be revised as “~~FFS:~~ For separate initial DL BWP used for paging, CD-SSB is included”.  **Proposal 1: Modify** **component 5 as following:**   * + 5. Separate initial DL BWP for RedCap UEes     - It includes CSS/CORESET for random access     - ~~FFS:~~ For separate initial DL BWP used for paging, CD-SSB is included     - For separate initial DL BWP only used for RACH, SSB may or may not be included   About issue#2 on FFS whether to add any other basic features for RedCap UE. In the last meeting, there were some discussions on the number of CORESETs the RedCap UE should monitor which may depend on whether the BWP contains the CORESET0 or not. The related proposal is listed below [3].  **Low priority proposal 2-5a:**   * **Add following components in FG 28-1:**   + **For FR1, support one ~~configured~~ PDCCH CORESET per BWP per cell in addition to CORESET0 if the BWP contains CORESET0, otherwise, support two ~~configured~~ PDCCH CORESETs per BWP per cell ~~in addition to CORESET0~~.**   + **For FR2, support two ~~configured~~ PDCCH CORESETs per BWP per cell in addition to CORESET0 if the BWP contains CORESET0, otherwise, support three ~~configured~~ PDCCH CORESETs per BWP per cell ~~in addition to CORESET0~~.**   Similar question also exists for legacy UE supporting FG6-1a. For legacy UE supporting FG6-1a, but not supporting FG3-3 for FR (see description for FG6-1a, FG3-3, FG3-1 component 1 below), it is not quite clear how many CORESETs a legacy UE needs to monitor within an active BWP in case the active BWP does not include the CORESET0.   * FG 6-1a: Active BWP may not include BW of the CORESET#0 (if CORESET#0 is present) and SSB for PCell/PSCell (if configured) * FG 3-1 component 1: One configured CORESET per BWP per cell in addition to CORESET0. * FG 3-3: More than one CORESET configurations per BWP in addition to CORESET0.   + FG3-3 is optional with capability signalling for FR1; and mandatory with capability signalling for FR2   From our understanding, a legacy UE is not required to monitor the CORESET0 outside the active BWP and there is no specification to specify that if the BWP does not contain CORESET0, the legacy UE supporting FG6-1a needs to support two configured PDCCH CORESETs per BWP per cell in addition to CORESET0. Therefore, RedCap UE does not need to have additional requirements compared to legacy UEs capable of FG6-1a.  **Observation 1: In case the active BWP does not include the CORESET0, the number of CORESETs required to be monitored by a legacy UE supporting FG6-1a is not clear and clarification is necessary.**  **Proposal 2: No additional requirements is added for RedCap UEs compared to legacy UEs capable of FG6-1a.**  In addition, CORESET0 is configured by MIB, its configuration and associated common search space is cell-specific, and mainly used for common signaling. The typical DCI formats monitored in CORESET0 are fallback DCIs, i.e., DCI format 0\_0 and 1\_0. The usage of CORESET0 is limited, not as flexible as the CORESET configured by UE specific signalling. Whether processing (UE-specific CORESET1 + UE-specific CORESET2) is more complex compared to processing (cell-specific CORESET0 + UE-specific CORESET1) is also not clear.  Given the main motivation for above Low priority proposal 2-5a is to give sufficient scheduling flexibility for the case that the BWP does not contain CORESET0, it is not the key target for the RedCap UEs and network can still use one CORESET other than CORESET0 in the active BWP for scheduling SIB1/OSIs etc. Without above proposal, the system can work well. Therefore, no need to add any other basic features for RedCap UE in FG28-1.  **Proposal 3: There is no need to add any other basic features for RedCap UE in FG28-1.** |
| [5] | CMCC | There are three cases for paging reception on separate initial DL BWP,   * Case 1: Separate initial DL BWP in idle/inactive mode. For this case, if it is configured for paging, CD-SSB is included. * Case 2: Separate initial DL BWP with BWP#0 configuration option 1 in connected mode, paging can only be configured if it contains CD-SSB (and CORESET#0 for FR1). * Case 3: Separate initial DL BWP with BWP#0 configuration option 2 in connected mode, if is configured for paging, CD-SSB/NCD-SSB is included for UE supporting mandatory FG 6-1(28-1) but not optional FG 6-1a(28-1a).   The reference agreements is copied as following. Case 1 and Case 2 are related to the FFS of component 5. According to TS38.331 B.2, BWP#0 configuration option 2 is considered as RRC-configured BWP, case 3 above is related to component 9 “UE-specific RRC configured DL BWP with CD-SSB or NCD-SSB”.  Agreement   * For BWP#0 configuration option 1,   + For FR1,     - For a separate initial DL BWP, for a RedCap UE in connected mode, paging can only be configured if it contains CD-SSB and the entire CORESET#0.   + For FR2,     - For a separate initial DL BWP, for a RedCap UE in connected mode, paging can only be configured if it contains CD-SSB. * Note: For BWP#0 configuration option 2,   + For FR1,     - For a separate initial DL BWP in connected mode (if it does not include CD-SSB and the entire CORESET#0), if it is configured for paging,       * A RedCap UE supporting mandatory FG 6-1 (but not optional FG 6-1a) expects it to contain NCD-SSB for serving cell but not CORESET#0/SIB       * A RedCap UE supporting FG 6-1a does not expect it to contain SSB/CORESET#0/SIB   + For FR2,     - For a separate initial DL BWP in connected mode (if it does not include CD-SSB), if it is configured for paging,       * A RedCap UE supporting mandatory FG 6-1 (but not optional FG 6-1a) expects it to contain NCD-SSB for serving cell but not CORESET#0/SIB       * A RedCap UE supporting FG 6-1a does not expect it to contain SSB/CORESET#0/SIB   So both case 1 and case 2 need to be reflected by the FFS, and considering that BWP#0 configuration option 1 is a concept of connected mode, we prefer to modify the FFS to the following,   * Separate initial DL BWP for RedCap UEs   + It includes CSS/CORESET for random access   + For separate initial DL BWP used for paging in idle/inactive mode or in connected mode as BWP#0 configuration option 1, CD-SSB is included.   + For separate initial DL BWP only used for RACH, SSB may or may not be included.   **Proposal 1: Modify the “FFS: For separate initial DL BWP used for paging, CD-SSB is included” part of separate initial DL BWP component of FG 28-1 to the following，**   * **~~FFS:~~** **For separate initial DL BWP used for paging in idle/inactive mode or in connected mode as BWP#0 configuration option 1, CD-SSB is included.**   And for the new agreements made during RAN1#109e for the BWP#0 configuration option 1, a new case 4 is introduced,   * Case 4: Separate initial DL BWP with BWP#0 configuration option 1 in connected mode, a RedCap UE supporting FG 28-1 but not FG 28-1a does not expect to operate in a separate initial DL BWP that does not include CD-SSB and the entire CORESET#0   A new sub-bullet for component 5 can be added to reflect basic RedCap UE behaviour of case 4.   * Separate initial DL BWP for RedCap UEs   + It includes CSS/CORESET for random access   + For separate initial DL BWP used for paging in idle/inactive mode or in connected mode as BWP#0 configuration option 1, CD-SSB is included.   + For separate initial DL BWP only used for RACH, SSB may or may not be included.   + For separate initial DL BWP in connected mode as BWP#0 configuration option 1, CD-SSB is included.   **Proposal 2: Add a new sub-bullet to separate initial DL BWP component of FG 28-1 as following，**   * + **For separate initial DL BWP in connected mode as BWP#0 configuration option 1, CD-SSB is included.** |
| [6] | MediaTek Inc. | For FG28-1, no additional components are needed to be added as basic features for RedCap UEs. |
| [7] | NTT DOCOMO, INC. | At the RAN1#108-e meeting, RAN1 made the following agreement which expects that paging can be configured for a separate initial DL BWP which does not include CD-SSB for BWP#0 configuration option 2 while paging can be configured for a separate initial DL BWP only when the separate initial DL BWP includes CD-SSB for BWP#0 configuration option 1.   |  | | --- | | **Agreement**           **The following working assumptions from RAN1#107-e are NOT confirmed for idle/inactive mode and furthermore they are replaced by the agreements further down for connected mode.**   * + **For FR1,**     - **For a separate initial DL BWP (if it does not include CD-SSB and the entire CORESET#0) from RAN1 perspective,**       * **Working assumption: If it is configured for paging, RedCap UE expects it to contain NCD-SSB for serving cell but not CORESET#0/SIB from RAN1 perspective**   + **For FR2,**     - **For a separate initial DL BWP (if it does not include CD-SSB~~and the entire CORESET#0~~) from RAN1 perspective,**       * **Working assumption: If it is configured for paging, RedCap UE expects it to contain NCD-SSB for serving cell but not CORESET#0/SIB from RAN1 perspective**            **For BWP#0 configuration option 1,**   * + **For FR1,**     - **For a separate initial DL BWP, for a RedCap UE in connected mode, paging can only be configured if it contains CD-SSB and the entire CORESET#0.**   + **For FR2,**     - **For a separate initial DL BWP, for a RedCap UE in connected mode, paging can only be configured if it contains CD-SSB.**            **Note: For BWP#0 configuration option 2,**   * + **For FR1,**     - **For a separate initial DL BWP in connected mode (if it does not include CD-SSB and the entire CORESET#0), if it is configured for paging,**       * **A RedCap UE supporting mandatory FG 6-1 (but not optional FG 6-1a) expects it to contain NCD-SSB for serving cell but not CORESET#0/SIB**       * **A RedCap UE supporting FG 6-1a does not expect it to contain SSB/CORESET#0/SIB**   + **For FR2,**     - **For a separate initial DL BWP in connected mode (if it does not include CD-SSB~~and the entire CORESET#0~~), if it is configured for paging,**       * **A RedCap UE supporting mandatory FG 6-1 (but not optional FG 6-1a) expects it to contain NCD-SSB for serving cell but not CORESET#0/SIB**       * **A RedCap UE supporting FG 6-1a does not expect it to contain SSB/CORESET#0/SIB** |   However, according to the RAN2 LS reply [3], it was concluded that if the separate initial DL BWP does not contain CD-SSB and CORESET#0, then this BWP will not be configured with paging for UEs in any RRC state and the RedCap UE in connected mode is not required to read paging for this case. Based on the conclusion, separate initial DL BWP which is used for paging needs to include CD-SSB regardless of BWP#0 configuration option and RRC state.  **Proposal 4-1: Remove “FFS” of FG28-1 component 5 and add “For separate initial DL BWP used for paging, CD-SSB is included” in FG28-1 component 5.**  Another remaining issue for FG28-1 is whether to add any other components in FG28-1.  According to FG3-1 which is supported by UE as a mandatory capability without signalling, legacy UEs support the configuration of one PDCCH CORESET for FR1 and two PDCCH CORESETs for FR2 per BWP per cell in addition to CORESET#0. However, for RedCap UEs, a DL BWP may not include the CORESET#0 in its BW and only one CORESET can be configured for such case while legacy UEs support two configurations of CORESET as a total for FR1. Accordingly, at the last RAN1 meeting, it was discussed whether to support one more configuration of CORESET per BWP per cell as basic feature of RedCap UE when a DL BWP for RedCap UEs does not include entire CORESET#0, but no consensus was achieved. Since the total number of configurations of CORESET is same as legacy UEs, it should be supported as part of FG28-1 to provide the same scheduling flexibility as legacy UEs.  **Proposal 4-2: Add the followings as components in FG28-1.**   * **For FR1, support one PDCCH CORESET per BWP per cell in addition to CORESET#0 if the BWP contains CORESET#0, otherwise, support two PDCCH CORESETs per BWP per cell.** * **For FR2, support two PDCCH CORESETs per BWP per cell in addition to CORESET#0 if the BWP contains CORESET#0, otherwise, support three PDCCH CORESETs per BWP per cell.** |
| [8] | Nokia, Nokia Shanghai Bell | * **28-1 - RedCap UE**   + Text under yellow highlights can be removed, as there is no need to repeat specifications in the FG list. Any issues regarding potential use of NCD-SSB by other devices are outside the scope of this discussion, given the decision on RAN#96 in [3]. |

Based on above, following proposals should be discussed at the RAN1#110 meeting.

### **High priority proposal 2-1-1:**

* **Apply ~~one of~~ the following ~~alternatives~~ for Component 5 of FG28-1**
  + **~~Alt.1-1:~~ Remove FFS and keep “For separate initial DL BWP used for paging, CD-SSB is included” [4, 7]**
  + **~~Alt.1-2: Remove~~ FFS ~~and~~ add following ~~two~~ sentence~~s~~ [5]**
    - **~~“For separate initial DL BWP used for paging in idle/inactive mode or in connected mode as BWP#0 configuration option 1, CD-SSB is included”~~**
    - **“For separate initial DL BWP in connected mode as BWP#0 configuration option 1, CD-SSB is included”**
  + **~~Alt.2: Remove “FFS: For separate initial DL BWP used for paging, CD-SSB is included” [8]~~**

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| Company | Comment |
| MediaTek | 1. Alt-1 should be supported to capture RAN2’s agreements. 2. In addition, Proposal 2 from CMCC (repeated below) can be added to capture RAN1 #109e agreements.  * For separate initial DL BWP by BWP#0 configuration option 1 in connected mode as BWP#0, CD-SSB is included. |
| vivo | Alt.1-1 based on RAN2 agreements. |
| ZTE, Sanechips | Alt.1-1 is supported. |
| FUTUREWEI | Alt.1-1 |
| CMCC | It seems there is a conflict between RAN1 and RAN2 agreements about SSB presence within BWP#0 configuration option2 in connected mode.  RAN1#108e made the following agreements.  Agreement: [38.213]   * The following working assumptions from RAN1#107-e are NOT confirmed for idle/inactive mode and furthermore they are replaced by the agreements further down for connected mode.   + For FR1,     - For a separate initial DL BWP (if it does not include CD-SSB and the entire CORESET#0) from RAN1 perspective,       * Working assumption: If it is configured for paging, RedCap UE expects it to contain NCD-SSB for serving cell but not CORESET#0/SIB from RAN1 perspective   + For FR2,     - For a separate initial DL BWP (if it does not include CD-SSB~~and the entire CORESET#0~~) from RAN1 perspective,       * Working assumption: If it is configured for paging, RedCap UE expects it to contain NCD-SSB for serving cell but not CORESET#0/SIB from RAN1 perspective * For BWP#0 configuration option 1,   + For FR1,     - For a separate initial DL BWP, for a RedCap UE in connected mode, paging can only be configured if it contains CD-SSB and the entire CORESET#0.   + For FR2,     - For a separate initial DL BWP, for a RedCap UE in connected mode, paging can only be configured if it contains CD-SSB ~~and the entire CORESET#0~~. * Note: For BWP#0 configuration option 2,   + For FR1,     - For a separate initial DL BWP in connected mode (if it does not include CD-SSB and the entire CORESET#0), if it is configured for paging,       * A RedCap UE supporting mandatory FG 6-1 (but not optional FG 6-1a) expects it to contain NCD-SSB for serving cell but not CORESET#0/SIB       * A RedCap UE supporting FG 6-1a does not expect it to contain SSB/CORESET#0/SIB   + For FR2,     - For a separate initial DL BWP in connected mode (if it does not include CD-SSB~~and the entire CORESET#0~~), if it is configured for paging,       * A RedCap UE supporting mandatory FG 6-1 (but not optional FG 6-1a) expects it to contain NCD-SSB for serving cell but not CORESET#0/SIB       * A RedCap UE supporting FG 6-1a does not expect it to contain SSB/CORESET#0/SIB   RAN2#118e made the following agreements   |  | | --- | | 29. Clarify in the RRC field description that the paging search space is configured in an initial BWP only if that BWP includes the CD-SSB.  30. RAN2 confirms that if RedCap-specific initial DL BWP does not contain CD-SSB and CORESET#0, then this BWP will not be configured with a paging search space in any RRC state. In this case, the RedCap UE in RRC\_CONNECTED state is not required to read paging.  31. Reply to RAN1 and explain there is no need to support paging connected RedCap UEs in a RedCap-specific initial DL BWP which does not contain CD-SSB and CORESET#0. |   How to handle such conflict? If the finial decision is to follow RAN2 agreements, then Alt1-1 can be adopted.  And what’s more, we think the second subbullet of Alt1-2 is also needed to reflect agreements made in RAN1#109e for BWP#0 configuration option 1. |
| NEC | Alt.1-1 |
| Nokia, NSB | Alt 1-1 |
| Nordic | Alt 1-1 |
| Ericsson | Alt 1-1 |
| Qualcomm | Alt 1-1 |
| Moderator (NTT DOCOMO) | Based on the feedbacks, we can take Alt.1-1. In addition, we can check whether the 2nd sentence in Alt.1-2 below should also be added.   * **Apply ~~one of~~ the following ~~alternatives~~ for Component 5 of FG28-1**   + **~~Alt.1-1:~~ Remove FFS and keep “For separate initial DL BWP used for paging, CD-SSB is included” [4, 7]**   + **~~Alt.1-2: Remove~~ FFS ~~and~~ add following ~~two~~ sentence~~s~~ [5]**     - **~~“For separate initial DL BWP used for paging in idle/inactive mode or in connected mode as BWP#0 configuration option 1, CD-SSB is included”~~**     - **“For separate initial DL BWP in connected mode as BWP#0 configuration option 1, CD-SSB is included”**   + **~~Alt.2: Remove “FFS: For separate initial DL BWP used for paging, CD-SSB is included” [8]~~** |
| CMCC | So it means RAN2 agreements is prioritized compared to RAN1, is it the right understanding?  And we think the FFS part is needed to reflect the agreement made in RAN1#109e.  Agreement   * For FR1, for BWP#0 configuration option 1, * In connected mode, a RedCap UE supporting FG 28-1 but not FG 28-1a does not expect to operate in a separate initial DL BWP that does not include CD-SSB and the entire CORESET#0. * In connected mode, a RedCap UE supporting both FG 28-1 and FG 28-1a is able to operate in a separate initial DL BWP that does not include CD-SSB and the entire CORESET#0. * For FR2, for BWP#0 configuration option 1, * In connected mode, a RedCap UE supporting FG 28-1 but not FG 28-1a does not expect to operate in a separate initial DL BWP that does not include CD-SSB. * In connected mode, a RedCap UE supporting both FG 28-1 and FG 28-1a is able to operate in a separate initial DL BWP that does not include CD-SSB. |

### **High priority proposal 2-1-2:**

* **Remove “FFS whether to add any other basic features for RedCap UE” ~~and apply one of the following alternatives for potential additional component~~ of FG28-1**
  + **~~Alt.1-1: Add component “Support one configured CORESET per BWP per cell in addition to CORESET0 if the BWP contains CORESET0, otherwise, support two configured CORESETs other than CORESET0 per BWP per cell, e.g. one common CORESET and one UE-specific CORESET” [2]~~**
  + **~~Alt.1-2: Add following components [7]~~**
    - **~~“For FR1, support one PDCCH CORESET per BWP per cell in addition to CORESET#0 if the BWP contains CORESET#0, otherwise, support two PDCCH CORESETs per BWP per cell”~~**
    - **~~“For FR2, support two PDCCH CORESETs per BWP per cell in addition to CORESET#0 if the BWP contains CORESET#0, otherwise, support three PDCCH CORESETs per BWP per cell”~~**
  + **~~Alt.2:~~ No additional component [4, 6, 8]**

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| Company | Comment |
| Vivo | Alt.2. There is no requirement defined for the legacy UE that supporting FG6-1a, but not supporting FG3-3 for FR1 needs to monitor two CORESETs within the active BWP in case the active BWP does not include the CORESET0. RedCap UE should not be more complex than legacy UE. |
| ZTE, Sanechips | If no new components are added, seems it is the same with legacy and we do not need to define it in FG28-1. So, we would be OK with either Alt.1-1 or Alt.2. |
| FUTUREWEI | Alt.1-1 |
| CMCC | Alt 1-1. |
| Nordic | Alt 2. We agreed to support FG3-1 by default which says: “One configured CORESET per BWP per cell in addition to CORESET0”. Is there really need to support two configured CORESETs? |
| Ericsson | Alt 1-2. |
| Qualcomm | Alt 2 |
| Moderator (NTT DOCOMO) | Based on the feedbacks, we can check if Alt.2 is agreeable.   * **Remove “FFS whether to add any other basic features for RedCap UE” ~~and apply one of the following alternatives for potential additional component~~ of FG28-1**   + **~~Alt.1-1: Add component “Support one configured CORESET per BWP per cell in addition to CORESET0 if the BWP contains CORESET0, otherwise, support two configured CORESETs other than CORESET0 per BWP per cell, e.g. one common CORESET and one UE-specific CORESET” [2]~~**   + **~~Alt.1-2: Add following components [7]~~**     - **~~“For FR1, support one PDCCH CORESET per BWP per cell in addition to CORESET#0 if the BWP contains CORESET#0, otherwise, support two PDCCH CORESETs per BWP per cell”~~**     - **~~“For FR2, support two PDCCH CORESETs per BWP per cell in addition to CORESET#0 if the BWP contains CORESET#0, otherwise, support three PDCCH CORESETs per BWP per cell”~~**   + **~~Alt.2:~~ No additional component [4, 6, 8]** |
| Huawei, HiSilicon | Both Alt1-1 and 1-2 is the same intention thus we can be open. Alt 1-2 seems more complete as including FR2.  For RedCap, since we already add NCD-SSB as mandatory feature, it is naturally to allow same total number of CORESETs as basic normal UE. For the mentioned 6-1a UE, it seems gNB can keep the total CORESETs as two by configuring CORESET0 in that BWP, even it does not include an SSB. We are open to hear more clarification nevertheless, the proposal does not exceed the normal basic UE capability as 6-1a is more advanced already if to compare with a 6-1a capable UE. |
| Ericsson | We prefer Alt 1-2, which offers similar flexibility as Rel-15 NR, this to avoid the need for separate handling by gNB of RedCap and non-RedCap UEs in this regard. Note that RAN1#110 has agreed that “A UE with reduced capabilities (RedCap UE) supports all Layer-1 UE features that are mandatory without capability signalling, unless stated otherwise.” |
| NTT DOCOMO | We support Alt.1-2 as a proponent and also fine with Alt.1-1 as 2nd preference. We would like to echo HW’s view. When CORESET#0 is not included in the DL BWP, and then the number of configurable CORESET is only one in the DL BWP especially for FR1 while the legacy UE, i.e., UE supporting FG3-1 which is mandatory feature without capability signaling, support two CORESET configurations as a total in DL BWP. |
| CMCC | Share similar view as Huawei, Ericsson and NTT DOCOMO, Alt1-2 can be adopted. |

### **High priority proposal 2-1-3:**

* **Add a note to exclude the support of following features for RedCap UE**
  + **UE capabilities exceeding 1Tx capability, e.g., FG 2-13, 2-14, 2-16b**
  + **Rel-17 eIAB and NR DC/CA further enhancements capabilities**
  + **Rel-17 above-52GHz and feMIMO capabilities, e.g., 23-1-1c, 23-1-1e, 23-1-1f, 23-1-1g, 23-8-3, 23-8-9, 23-9-3**
  + **[Rel-17 MBS capabilities]**

|  |  |
| --- | --- |
| Company | Comment |
| MediaTek | We support FL’s proposal 2-1-3. |
| Vivo | We are fine with excluding UE capabilities exceeding 1Tx capability, Rel-17 eIAB and NR DC/CA further enhancements capabilities and Rel-17 above-52GHz and feMIMO capabilities.  About “Rel-17 eIAB and NR DC/CA further enhancements capabilities”, it was already stated in 38.306 that “CA, MR-DC, DAPS, CPAC and IAB (i.e., the RedCap UE is not expected to act as IAB node) related UE features and corresponding capabilities are not supported by RedCap Ues. All other feature groups or components of the feature groups as captured in TR 38.822 [24] as well as capabilities specified in this specification remain applicable for RedCap Ues same as non-RedCap Ues, unless indicated otherwise”  For Rel-17 MBS capabilities, we do not support to exclude it for RedCap. |
| ZTE, Sanechips | We support the FL’s proposal. |
| FUTUREWEI | Do not support FL proposal:  Regarding 1st bullet (1Tx): It should be removed – we had this discussion regarding 1TX in FL summary R1-2112503 with the conclusion “Since there is no consensus for this proposal, it is recommended to not consider it further in this meeting”  Regarding 2nd bullet: not needed – if RedCap UE does not support eIAB not NR DC/CA, it will not support the enhancements  Regarding 3rd bullet: we note that there are some capabilities (e.g. BW) that exceed RedCap Ues capabilities, a blanket exclusion of above 52 GHz is not needed. Likewise for feMIMO – there may be some RedCap Ues supporting 2 Rx.  Regarding 4th bullet – MBS capabilities should not be excluded for RedCap |
| CMCC | For the MBS part, the approved LS with Tdoc number RP- 221861 in RAN#96 to SA2 has the following contents, and the LS is drafted according to agreed proposal on RP-221782 RedCap UE MBS support, off-line discussion summary  RAN would like to thank SA2 for the LS R1-2203128(S2-2203020) on UE capabilities of MBS.  The following is RAN’s response:   * RAN#96 has concluded that Rel-17 specifications do not prevent any UE, including RedCap Ues, to support MBS.   So the it seems not correct to exclude R17 MBS capabilities. |
| Nokia, NSB | Do not support the proposal. There is no support from WID or WI activity to discard >1TX support. As for eIAB and NR DC/CA they should be out of scope by definition already by lack of CA support. Similar reasoning applies for other cases too. As for MBS it is not clear why it would be explicitly excluded. In fact there is an LS from RAN#96 saying the contrary (R1-2205726): RAN#96 has concluded that Rel-17 specifications do not prevent any UE, including RedCap Ues, to support MBS. |
| Ericsson | We do not support the proposal. We share the views expressed by Futurewei, CMCC, and Nokia. |
| Qualcomm | We can live with the first two bullets of FL’s proposal.  We have concerns for the last bullet. Based on the conclusion of RAN#96 meeting, UE capabilities of NR R17 MBS can be optionally supported by R17 RedCap UE. |
| Moderator (NTT DOCOMO) | Based on the feedbacks, there seems to be no consensus on the proposal given RAN#96 conclusion. |

## **2.2 28-1a: RRC-configured DL BWP without CD-SSB or NCD-SSB**

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 28. NR\_redcap | 28-1a | RRC-configured DL BWP without CD-SSB or NCD-SSB | RRC-configured DL BWP without CD-SSB or NCD-SSB  FFS whether to add additional components | 28-1 | Yes |  |  | Per band | N/A | N/A |  |  | Optional with capability signaling |

Following views are provided in contributions for the RAN1#110 meeting.

|  |  |  |  |
| --- | --- | --- | --- |
| [4] | vivo | FG 28-1a is an FG for RRC-configured DL BWP without CD-SSB or NCD-SSB. There is one FFS on whether to add additional components. The additional components should be related to how a RedCap UE can measure SSB outside the RRC-configured DL BWP for BM/BFD/RLM/RRM.  In the RAN1#108-e meeting, following conclusion was made and related LS [4] was also sent to RAN4 with the information that “its related UE feature discussion (including measurement gaps) is up to RAN4”. Therefore, there is no need for RAN1 to continue the discussion on how to capture such additional components.   |  | | --- | | **Conclusion:**   * From RAN1 perspective, whether and under what conditions a RedCap UE requires to be configured with existing measurement gaps to support operation without SSB in an RRC-configured active BWP, and its related UE feature discussion (including measurement gaps) is up to RAN4. * Send an LS to RAN4 to inform them about the conclusion. |   **Proposal 4: For FG28-1a, remove the “FFS whether to add additional components” from RAN1 perspective.**   * **Note that for FG28-1a, the related UE feature discussion (including measurement gaps) is up to RAN4.** |
| [5] | CMCC | Based on the above agreements, when UE support optionally capability, the relevant operation is based on [FG 6-1a] with supporting CSI-RS, or [FG 6-1a]without supporting CSI-RS. And according to the RAN4 conclusion, RedCap UE can perform RLM, BFD, CBD and L1 RSRP measurement based on CSI-RS and L3 measurement based on CSI-RS with associated SSB if UE supports the corresponding capabilities. If the corresponding capabilities are not supported, UE may rely on re-tuning to CD-SSB for such measurement, which may be already supported as FG6-1a and can be UE behaviors based on implementation. So we propose to add the following components to FG28-1a,   * Measurement operation based on FG6-1a. * RLM, BFD, CBD and L1 RSRP measurement based on CSI-RS if UE reports the corresponding capabilities. * CSI-RS based L3 measurement with associated SSB if UE reports the corresponding capability.   And the prerequisite feature group of this new feature can be FG 6-1a.  **Proposal 3: Include the following components to FG28-1a,**   * **Measurement operation based on FG6-1a.** * **RLM, BFD, CBD and L1 RSRP measurement based on CSI-RS if UE reports the corresponding capabilities.** * **CSI-RS based L3 measurement with associated SSB if UE reports the corresponding capability.**   **Proposal 4: The prerequisite feature groups of FG28-1a are FG28-1 and FG 6-1a.**  Currently, the component of FG28-1a only mentions about RRC configured BWP. Except the RRC configured BWP, separated initial DL BWP without UE dedicated BWP configuration is also related to FG28-1a, as highlighted in the following agreements.  Agreement   * For FR1, for BWP#0 configuration option 1, * In connected mode, a RedCap UE supporting FG 28-1 but not FG 28-1a does not expect to operate in a separate initial DL BWP that does not include CD-SSB and the entire CORESET#0. * In connected mode, a RedCap UE supporting both FG 28-1 and FG 28-1a is able to operate in a separate initial DL BWP that does not include CD-SSB and the entire CORESET#0. * For FR2, for BWP#0 configuration option 1, * In connected mode, a RedCap UE supporting FG 28-1 but not FG 28-1a does not expect to operate in a separate initial DL BWP that does not include CD-SSB. * In connected mode, a RedCap UE supporting both FG 28-1 and FG 28-1a is able to operate in a separate initial DL BWP that does not include CD-SSB.   Since the BWP#0 configuration option 1 is not belong to RRC configured BWP, one component about BWP#0 configuration option 1 without CD-SSB should be included to FG28-1a based on above agreements. The component can be as following,   * BWP#0 configuration option 1 without CD-SSB.   **Proposal 5: Include the following component to FG28-1a,**   * **BWP#0 configuration option 1 without CD-SSB.** |
| [6] | MediaTek Inc. | For FG28-1a, to operate on a BWP containing no SSBs, current specifications clearly state that L1 measurements can be only performed based on CSI-RS as suggested in TS38.300. The specifications are hence complete, and no additional components are needed for FG2 8-1a.   |  | | --- | | 9.2.3.1 Overview  […] SSB-based Beam Level Mobility is based on the SSB associated to the initial DL BWP and can only be configured for the initial DL BWPs and for DL BWPs containing the SSB associated to the initial DL BWP. For other DL BWPs, Beam Level Mobility can only be performed based on CSI-RS.  9.2.7 Radio Link Failure  […] SSB-based RLM is based on the SSB associated to the initial DL BWP and can only be configured for the initial DL BWP and for DL BWPs containing the SSB associated to the initial DL BWP. For other DL BWPs, RLM can only be performed based on CSI-RS.  9.2.8 Beam failure detection and recovery  […] SSB-based Beam Failure Detection is based on the SSB associated to the initial DL BWP and can only be configured for the initial DL BWPs and for DL BWPs containing the SSB associated to the initial DL BWP. For other DL BWPs, Beam Failure Detection can only be performed based on CSI-RS. |   Proposal 2: For FG 28-1 and FG 28-1a, no additional components are needed. Remove the FFS points and conclude the two feature groups. |
| [7] | NTT DOCOMO, INC. | It was also agreed at the meeting in the discussion on maintenance for RedCap as follows;   |  | | --- | | Agreement at RAN1 #109-e   * For FR1, for BWP#0 configuration option 1,   + In connected mode, a RedCap UE supporting FG 28-1 but not FG 28-1a does not expect to operate in a separate initial DL BWP that does not include CD-SSB and the entire CORESET#0.   + In connected mode, a RedCap UE supporting both FG 28-1 and FG 28-1a is able to operate in a separate initial DL BWP that does not include CD-SSB and the entire CORESET#0. * For FR2, for BWP#0 configuration option 1,   + In connected mode, a RedCap UE supporting FG 28-1 but not FG 28-1a does not expect to operate in a separate initial DL BWP that does not include CD-SSB.   + In connected mode, a RedCap UE supporting both FG 28-1 and FG 28-1a is able to operate in a separate initial DL BWP that does not include CD-SSB. |   Based on this agreement, if a RedCap UE supports FG28-1a in addition to FG28-1, it can operate in a separate initial DL BWP that does not include CD-SSB in RRC connected mode, and hence at least this description needs to be captured as an additional component in FG28-1a.  **Proposal 4-3: Add the following as a component in FG28-1a.**   * **For BWP#0 configuration option 1, in RRC connected mode, support operation in a separate initial DL BWP that does not include CD-SSB.**   In addition, it was discussed whether to add the capability of SSB measurement outside the RRC-configured DL BWP for RLM/RRM/BM/BFD and suggested by FL to wait the outcome of the discussion for LS on BWP operation without bandwidth restriction [4] at the RAN1#109-e meeting. Regarding the discussion status for the BWP operation without bandwidth restriction, at the RAN#96 meeting, it was agreed that each WG would work to ensure the solution for FG6-1a related issues and a new UE feature for SSB measurement outside the DL BWP for RLM/BM/BFD without gap would be specified as Rel-17 UE feature or Rel-18 early implementation.  For a RedCap UE, it is assumed that if a DL BWP does not include SSB, then it implies that SSB would exist outside the RedCap UE’s RF BW, and it would require measurement gap to measure the SSB outside the BWP. However, regarding the new UE capability for UE supporting FG6-1a described above, the SSB outside BWP is expected to be confined within UE’s RF BW and it is not sure whether the measurement gap would be required or not to measure the SSB outside the BWP so far. In that sense, the UE capability for SSB measurement outside DL BWP with measurement gap should be specified especially for RedCap UEs at least for RLM and RRM. Furthermore, measurement of the SSB outside BWP can be used even for BM/BFD if a RedCap UE supports UE capabilities related to BM/BFD based on SSB measurement.  **Proposal 4-4: Add the following as a component in FG28-1a.**   * **Measurement of SSB outside the RRC-configured DL BWP for RLM/RRM and BM/BFD (if supported)** |
| [8] | Nokia, Nokia Shanghai Bell | * **28-1a - RRC-configured DL BWP without CD-SSB or NCD-SSB**   + No need for further components |
| [9] | NEC | To avoid the issue for RedCap UE, one possible way would be FG28-1a includes capability of CSI-RS based RLM (same feature as FG1-7), where RedCap UE capable of FG28-1a does not need to support FG1-7. Or, considering RedCap UE only support PCell, it would also be possible to make FG1-7 a prerequisite of FG28-1a. Merit of these approach would be it is possible to make reuse of existing specifications as much as possible.  Another possible way would be FG28-1a include SSB-based BM/RLM/BFD which would be discussed for non-RedCap UE as a new feature in relation with the RAN2 LS [1]. This approach would require some impact on RAN1 specifications and a new requirement in RAN4.  Our preference would be the first way to reuse existing specifications considering Rel-17 has been in CR phase for some time.  **Proposal:**   * Include capability of CSI-RS based RLM (FG1-7) into FG28-1a and reuse existing specifications for RLM on PCell |

Based on above, following proposal should be discussed at the RAN1#110 meeting.

### **High priority proposal 2-2:**

* **Remove “FFS whether to add additional components” and apply one of the following alternatives for potential additional component of FG28-1a**
  + **Alt.1: Add following components [and add FG6-1a as prerequisite FG] [5, 7]**
    - **“For BWP#0 configuration option 1, in RRC connected mode, support operation in a separate initial DL BWP that does not include CD-SSB”**
    - **“Measurement of SSB outside the RRC-configured DL BWP for RLM/RRM and BM/BFD (if supported)”**
  + **Alt.2: Add following component [9]**
    - **CSI-RS based RLM (and add FG1-7 as prerequisite FG)**
  + **Alt.3: No additional component [4, 6, 8]**

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| Company | Comment |
| MediaTek | We can support Alt.2 and the first sub-bullet of Alt1. However, we cannot accept the second component of Alt.1. This is just not compliant to current specifications. Due to reduced maximum UE BW, a gap is required for RedCap to perform measurements outside its BWP. Hence, we suggest revise it as follows:   * Measurement of SSB outside the RRC-configured DL BWP for RLM/RRM and BM/BFD (if supported) **with a measurement gap**. |
| Vivo | Alt.3. Related UE features should be discussed and captured by RAN4 based on the conclusion and LS. |
| ZTE, Sanechips | For alt.2 and second bullet of Alt.1, we’d better to wait for the conclusion of discussion on BWP without SSB in NR, since they are not RedCap specific components. For first bullet of Alt.1, we are OK to consider. |
| CMCC | For the first subbullet of Alt.1, the following description is more aligned with the current component “RRC-configured DL BWP without CD-SSB or NCD-SSB”,   * **BWP#0 configuration option 1 without CD-SSB.**   And for the measurement related component, it has capture “10. NCD-SSB based measurements in RRC-configured DL BWP” in FG28-1, so we think CSI-RS related feature also needs to be captured in FG 28-1a. such as   * **RLM, BFD, CBD and L1 RSRP measurement based on CSI-RS if UE reports the corresponding capabilities.** * **CSI-RS based L3 measurement with associated SSB if UE reports the corresponding capability.** |
| NEC | Similar view as ZTE. |
| Nokia, NSB | Alt 3. |
| Nordic | Alt 3. Agree with VIVO |
| Ericsson | The first sub-bullet of Alt.1 seems to be in line with the RAN1#109-e agreements, but we are not sure it needs to be listed as a component.  The second sub-bullet of Alt.1, and Alt.2, seem to go beyond what we can agree in RAN1, at least at this point. |
| Qualcomm | Alt 3 |
| Moderator (NTT DOCOMO) | Based on the feedbacks, we may need to check the outcome of the discussion on FG6-1a. |
| Huawei, HiSilicon | For Alt 1 first bullet, it may be further refined to say ‘not include any SSB’. We are also ok with Alt3 and this can let RAN4 decide. |
| CMCC | At least for the first bullet of Alt1, the intention is to capture the agreements made in RAN1#109e.  we think the following description is more aligned with the current component “RRC-configured DL BWP without CD-SSB or NCD-SSB”,   1. RRC-configured DL BWP without CD-SSB or NCD-SSB   2. BWP#0 configuration option 1 without CD-SSB.  FFS whether to add additional components  To Huawei, it is BWP#0 configuration option 2, so no CD-SSB is configured. |

# **Conclusions**

TBD

# **2References**

[1] R1-2205608 Updated RAN1 UE features list for Rel-17 NR after RAN1 #109-e including remaining RAN1 issues Moderators (AT&T, NTT DOCOMO, INC.)

[2] R1-2205787 On UE features for other Rel-17 work items Huawei, HiSilicon

[3] R1-2205914 Discussion on some remaining issues of Rel-17 UE features ZTE

[4] R1-2206770 Other remaining issues for Rel-17 UE features (RedCap, B52.6GHz) vivo

[5] R1-2206893 Discussion on UE features for RedCap CMCC

[6] R1-2207001 Remaining issues on R17 UE features MediaTek Inc.

[7] R1-2207392 Discussion on remaining issues in RAN1 UE features list for Rel-17 NR NTT DOCOMO, INC.

[8] R1-2207584 On UE features for miscellaneous topics Nokia, Nokia Shanghai Bell

[9] R1-2206416 Remaining details on BWP operation for RedCap NEC