3GPP TSG RAN WG2 Meeting #116-e R2-210xxxx

**Electronic meeting, 1st -12th November 2021**

**Agenda item:** 8.12.2.1

**Source:** Intel Corporation

**Title:** Report of email discussion [Post115-e][108][RedCap] 38.306 Running CR (Intel)

**Document for:**  Discussion and decision

# Introduction

This is the email discussion report for following email discussion:

* [Post115-e][108][RedCap] 38.306 Running CR (Intel)

Scope: draft 38.306 running CR based on meeting agreements, also trying to resolve structural open issues from R2-2108891 (e.g. reusing existing sections/fields vs introducing new ones, etc.)

Intended outcome: Endorsable 38.306 running CR

Deadline: Long

Rapporteur would like to split the discussion in two phases:

**Phase 1**: To check the proposals from Rapporteur and the draft TP; The **deadline for this 1st phase** of email discussion is **Wednesday Oct 13 , 0900 UTC.**

**Phase 2**: To finalize the draft running CR; The **deadline for this 2nd phase** of email discussion is **Wednesday Oct 20 , 0900 UTC.**

# Annex: companies’ point of contact

|  |  |  |
| --- | --- | --- |
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# Phase 1the draft on how to capture meeting agreements

At RAN2#115-e, based on [1], [2] and [3], RAN2 discussed RedCap UE capabilities and agreed:

Agreements:

1. The number of DRBs supported by RedCap UEs is less than legacy value (which is 16). There will be a single mandatory value (FFS if 4 or 8). FFS if it will be possible to have an optional capability
2. “RRC processing delay” is not relaxed for RedCap UE
3. PDCP/RLC AM 12 bits SN is mandatory for RedCap UE, and PDCP/RLC AM 18bits SN is optional supported by RedCap UE; FFS on how to capture this in specification
4. NE-DC, and (NG)EN-DC are not supported by RedCap UE; FFS on how to capture it in the specification
5. DAPS and CAPC related capabilities are not applicable for RedCap UE; [8/20] FFS on CHO. FFS on how to capture this in the specification;

Agreements via email - from offline 109:

1. Maximum 8 DRBs is mandatory supported by RedCap UEs.
2. From RAN2 perspective, inter RAT mobility related capabilities are applicable for RedCap UE;
3. From RAN2 perspective, measurement related capabilities are applicable for RedCap UE;
4. From RAN2 perspective, URLLC related capabilities are applicable for RedCap UE except those affected by CA/DC;
5. From RAN2 perspective, IAB related capabilities are not applicable for RedCap UE, i.e. the RedCap UE is not expected to act as IAB node;
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;

Based on agreements, Rapporteur believes following should be captured in TS38.306:

* 1 PDCP/RLC AM 12 bits SN is mandatory for RedCap UE, and PDCP/RLC AM 18bits SN is optional supported by RedCap UE;
* 2 Maximum 8 DRBs is mandatory supported by RedCap UEs.
* 3 DAPS and CAPC related capabilities are not applicable for RedCap UE;
* 4 From RAN2 perspective, IAB related capabilities are not applicable for RedCap UE, i.e. the RedCap UE is not expected to act as IAB node;

In addition, as discussed in [1], [2], following also should be captured:

* 5 Maximum BW (proposal 9 in [2]);
* 6 MIMO limitation (proposal 11 in [2]);
* 7 Modulation (proposal 20 in [1])
* 8 NE-DC, and (NG)EN-DC are not supported by RedCap UE; Note: It should be captured together with CA/MR-DC case; CA/DC (proposal 19 in [1]);

**Discussion point 1: Any additional agreements need be captured?**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Apple |  | RedCap UE is allowed to supported more than the mandatory DRB of 8. |
|  |  |  |

## How to capture the agreements on PDCP/RLC AM SN;

* 1 PDCP/RLC AM 12 bits SN is mandatory for RedCap UE, and PDCP/RLC AM 18bits SN is optional supported by RedCap UE;

According to 4.2.4 of TS38.306, so far 12 bits SN is mandatory for non-RedCap UE. Therefore we do not need to clarify that this is also applicable for RedCap UE since based on RAN2 Working Assumption: by default, all non-RedCap UE capabilities are applicable for RedCap UE, and therefore only for non-RedCap capabilities that are not appliable for RedCap UE, we clarify in the definitions for parameters in TS38.306, the value or feature is not applicable for RedCap UE.

|  |  |  |  |
| --- | --- | --- | --- |
| Definitions for parameters | Per | M | FDD-TDD DIFF |
| ***shortSN***  Indicates whether the UE supports 12 bit length of PDCP sequence number. | UE | Yes | No |

|  |  |  |  |
| --- | --- | --- | --- |
| Definitions for parameters | Per | M | FDD-TDD DIFF |
| ***am-WithShortSN***  Indicates whether the UE supports AM DRB with 12 bit length of RLC sequence number. | UE | Yes | No |

**Observation 1: PDCP parameter *shortSN* and RLC parameter *am-WithShortSN* are also applicable for redcap UE, and therefore no change is needed for 12 bits SN;**

However for non-RedCap UE, 18 bits SN is mandatory without capability bit. Therefore we need to introduce a capability bit for RedCap UE, i.e. both TS38.331 and TS38.306 need to be changed.

#### TS38.331 TP on PDCP/RLC 18 bits SN

– *PDCP-Parameters*

The IE *PDCP-Parameters* is used to convey capabilities related to PDCP.

***PDCP-Parameters* information element**

-- ASN1START

-- TAG-PDCP-PARAMETERS-START

PDCP-Parameters ::= SEQUENCE {

supportedROHC-Profiles SEQUENCE {

profile0x0000 BOOLEAN,

profile0x0001 BOOLEAN,

profile0x0002 BOOLEAN,

profile0x0003 BOOLEAN,

profile0x0004 BOOLEAN,

profile0x0006 BOOLEAN,

profile0x0101 BOOLEAN,

profile0x0102 BOOLEAN,

profile0x0103 BOOLEAN,

profile0x0104 BOOLEAN

},

maxNumberROHC-ContextSessions ENUMERATED {cs2, cs4, cs8, cs12, cs16, cs24, cs32, cs48, cs64,

cs128, cs256, cs512, cs1024, cs16384, spare2, spare1},

uplinkOnlyROHC-Profiles ENUMERATED {supported} OPTIONAL,

continueROHC-Context ENUMERATED {supported} OPTIONAL,

outOfOrderDelivery ENUMERATED {supported} OPTIONAL,

shortSN ENUMERATED {supported} OPTIONAL,

pdcp-DuplicationSRB ENUMERATED {supported} OPTIONAL,

pdcp-DuplicationMCG-OrSCG-DRB ENUMERATED {supported} OPTIONAL,

...,

[[

drb-IAB-r16 ENUMERATED {supported} OPTIONAL,

non-DRB-IAB-r16 ENUMERATED {supported} OPTIONAL,

extendedDiscardTimer-r16 ENUMERATED {supported} OPTIONAL,

continueEHC-Context-r16 ENUMERATED {supported} OPTIONAL,

ehc-r16 ENUMERATED {supported} OPTIONAL,

maxNumberEHC-Contexts-r16 ENUMERATED {cs2, cs4, cs8, cs16, cs32, cs64, cs128, cs256, cs512,

cs1024, cs2048, cs4096, cs8192, cs16384, cs32768, cs65536} OPTIONAL,

jointEHC-ROHC-Config-r16 ENUMERATED {supported} OPTIONAL,

pdcp-DuplicationMoreThanTwoRLC-r16 ENUMERATED {supported} OPTIONAL

]],

[[

longSN-RedCap-r17 ENUMERATED {supported} OPTIONAL

]]

}

-- TAG-PDCP-PARAMETERS-STOP

-- ASN1STOP

– *RLC-Parameters*

The IE *RLC-Parameters* is used to convey capabilities related to RLC.

***RLC-Parameters* information element**

-- ASN1START

-- TAG-RLC-PARAMETERS-START

RLC-Parameters ::= SEQUENCE {

am-WithShortSN ENUMERATED {supported} OPTIONAL,

um-WithShortSN ENUMERATED {supported} OPTIONAL,

um-WithLongSN ENUMERATED {supported} OPTIONAL,

...,

[[

extendedT-PollRetransmit-r16 ENUMERATED {supported} OPTIONAL,

extendedT-StatusProhibit-r16 ENUMERATED {supported} OPTIONAL

]],

[[

am-WithLongSN-RedCap-r17 ENUMERATED {supported} OPTIONAL

]]

}

-- TAG-RLC-PARAMETERS-STOP

-- ASN1STOP

#### TS38.306 TP on PDCP/RLC 18 bits SN- Option 1 capture under normal capability sections

|  |  |  |  |
| --- | --- | --- | --- |
| **Definitions for parameters** | **Per** | **M** | **FDD-TDD DIFF** |
| ***jointEHC-ROHC-Config-r16***  Indicates whether the UE supports simultaneous configuration of EHC and ROHC protocols for the same DRB. | UE | No | No |
| ***longSN-RedCap-r17***  Indicates whether the RedCap UE supports 18 bit length of PDCP sequence number. This capability is only applicable for RedCap UEs. | UE | No | No |
| ***maxNumberROHC-ContextSessions***  Defines the maximum number of ROHC header compression context sessions supported by the UE, excluding context sessions that leave all headers uncompressed. | UE | No | No |

|  |  |  |  |
| --- | --- | --- | --- |
| Definitions for parameters | Per | M | FDD-TDD DIFF |
| ***am-WithLongSN-RedCap-r17***  Indicates whether the RedCap UE supports AM DRB with 18 bit length of RLC sequence number. This capability is only applicable for RedCap UEs. | UE | No | No |
| ***am-WithShortSN***  Indicates whether the UE supports AM DRB with 12 bit length of RLC sequence number. | UE | Yes | No |
| ***extendedT-PollRetransmit-r16***  Indicates whether the UE supports the additional values of *T-PollRetransmit timer*. The supported additional values are 1ms, 2ms, 3ms and 4ms, as specified in TS 38.331 [9]. | UE | No | No |
| ***extendedT-StatusProhibit-r16***  Indicates whether the UE supports the additional values of *T-StatusProhibit timer*. The supported additional values are 1ms, 2ms, 3ms and 4ms, as specified in TS 38.331 [9]. | UE | No | No |
| ***um-WithLongSN***  Indicates whether the UE supports UM DRB with 12 bit length of RLC sequence number. | UE | Yes | No |
| ***um-WithShortSN***  Indicates whether the UE supports UM DRB with 6 bit length of RLC sequence number. | UE | Yes | No |

#### TS38.306 TP on PDCP/RLC 18 bits SN- Option 2 capture under Redcap specific sections [6]

4.2.xx RedCap parameters

4.2.xx.x PDCP Parameters

| **Definitions for parameters** | **Per** | **M** | **FDD-TDD**  **DIFF** |
| --- | --- | --- | --- |
| ***longSN-RedCap-r17***  Indicates whether the RedCap UE supports 18 bit length of PDCP sequence number. This capability is only applicable for RedCap UEs. | UE | No | No |

4.2.xx.y RLC Parameters

| **Definitions for parameters** | **Per** | **M** | **FDD-TDD**  **DIFF** |
| --- | --- | --- | --- |
| ***am-WithLongSN-RedCap-r17***  Indicates whether the RedCap UE supports AM DRB with 18 bit length of RLC sequence number. This capability is only applicable for RedCap UEs. | UE | No | No |

**Companies are invited to provide your view on the TP for PDCP/RLC SN shown as above, and which options (TS38.306) are preferred. Also please indicate if anything is missing.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company’s name** | **Agree or not** | **Option1/2?** | **Comments, if any** |
| Huawei, HiSilicon | Agree;  No for 12 bits case | Option 2 | Option 2 is more readable. Also, there may be more RAN1/4 RedCap specific parameters to be captured, it is always good to gather RedCap related capabilities together. Please see the R16 cases of V2X and IAB to capture in their specific section 4.2.15/16.  On the “PDCP/RLC AM 12 bits SN is mandatory for RedCap UE”, we have different understanding on  **Observation 1: PDCP parameter *shortSN* and RLC parameter *am-WithShortSN* are also applicable for redcap UE, and therefore no change is needed for 12 bits SN;**  It was “Mandatory with capability signalling” for non-RedCap UE, but it should be always set to 1 for RedCap UE (more like mandatory without singalilng).  Therefore, we should also clarify that PDCP/RLC AM 12 bits SN is mandatory for RedCap UE. We prefer to capture this as one sub-clause in the RedCap specific section as “Mandatory features for RedCap”. |
| Apple | Agree. | No strong view, ok with majority. | We slightly prefer 18bit to be present in the field name than ‘long’, as it is clearer. But again no strong stance here.  We also agree with Huawei’s comments on 12-bit PDCP/RLC comment on mandatory support. |
| OPPO | Agree | Option 1/2 | No strong view, both options are ok for us.  We also agree with Huawei’s comments on 12-bit PDCP/RLC comment on mandatory support. |
| Futurewei | Agree | No strong view on either | But agree to add a statement that the support of 12 bit length of PDCP or RLC SN is mandatory for RedCap UEs. |
| CATT | Agree with comments | Option 2 | We suggest to include some clarification on the following working assumption, not just for 12-bit. Otherwise, a produce developer , who has not followed the standard discussion, may have confusion that, e.g., whether the 12-bit is applicable for Redcap UE or not:  1. RAN2 Working Assumption: by default, all non-RedCap UE capabilities are applicable for RedCap UE, and therefore only for non-RedCap capabilities that are not eighbore for RedCap UE, we clarify in the definitions for parameters in TS38.306, the value or feature is not applicable for RedCap UE |
| Samsung | Agree | Option 2 | We prefer capturing in RedCap specific section, and agree with Huawei (i.e., clarify that PDCP/RLC AM 12 bits SN is mandatory for RedCap UE.) |
| Vivo | Agree | Option 2 | We prefer option 2, which is more readable and clean for RedCap features.  Besides, we also agree Huawei the corresponding clarification on mandatorily support on 12-bit SN should be captured in spec TS 38.306. |

## How to capture the agreements on maximum DRB;

* 3 Maximum 8 DRBs is mandatory supported by RedCap Ues.

#### TS38.306 TP on maximum DRB

| Parameter | Description | Value |
| --- | --- | --- |
| #DRBs | The number of DRBs that a UE shall support. | 16 per UE.  8 per UE, only for RedCap Ues.  NOTE 1  NOTE 3 |
| #minCellperMeasObjectNR | The minimum number of eighbor cells (excluding black list cells) that a UE shall be able to store associated with a MeasObjectNR. | 32  NOTE 2 |
| #minBlackCellRangesperMeasObjectNR | The minimum number of blacklist cell PCI ranges that a UE shall be able to store associated with a MeasObjectNR. | 8 |
| #minBlackCellperMeasObjectEUTRA | The minimum number of blacklist cells that a UE shall be able to store associated with a MeasObjectEUTRA. | 32 |
| #minCellperMeasObjectEUTRA | The minimum number of eighbor cells that a UE shall be able to store associated with a MeasObjectEUTRA. | 32  NOTE 2 |
| #minCellTotal | The minimum number of eighbor cells (excluding black list cells) that UE shall be able to store in total from all measurement objects configured. | 256 with counting CSI-RS and SSB as 2. |
| #maxDeprioritisationFreq | The UE shall be able to store a depriotisation request for up to 8 frequencies (applicable when receiving another frequency specific deprioritisation request via *RRCRelease* before T325 expiry). | 8 |
| #minCellperMeasObjectUTRA-FDD | The minimum number of eighbor cells that a UE shall be able to store associated with a MeasObjectUTRA-FDD. | 32 |
| NOTE 1: For one MAC entity, the maximum number of DRBs configured with PDCP duplication and with RLC entity(ies) associated with this MAC entity is 8.’This is not applicable for RedCap Ues.  NOTE 2: In case of CGI reporting, the limit regarding the cells configured includes the cell for which the UE is requested to report CGI i.e. the amount of eighbor cells that can be included is at most (# minCellperMeasObjectRAT – 1), where RAT represents NR and EUTRA.  NOTE 3: This requirement is applicable in NR SA, NR-DC and NE-DC. | | |

**Companies are invited to provide your view on the TP for maximum DRB shown as above. Also please indicate if anything is missing.**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Agree or not** | **Comments, if any** |
| Huawei, HiSilicon | Agree, but | It is better to also clarify this in the RedCap specific section. Maybe together with the PDCP/RLC AM 12 bits SN. |
| Apple | Needs clarification | The table should convery the maximum **mandatory** supported value for DRB. This should also mean a RedCap UE can support more than 8 DRBs. The proposed text needs this clarification.  Maybe we can say “ atleast 8 per UE, only for RedCap Ues”. But we assume this needs discussion in RAN2. |
| OPPO | Agree |  |
| Futurewei | Partially agree. | Suggested change #1:  16 per UE, for non-RedCap Ues.  8 per UE, for RedCap Ues.  Suggested change #2:  NOTE 1: For one MAC entity, the maximum number of DRBs configured with PDCP duplication and with RLC entity(ies) associated with this MAC entity is 8.’This exception is not applicable for RedCap Ues. |
| CATT |  | Agree with Futurewei |
| Samsung | Agree, but | Agree with Huawei. |
| vivo | Agree with comments | 16 per UE, for non-RedCap UEs  8 per UE, ~~only~~ for RedCap Ues. |

## How to capture the agreements on DAPS and CAPC related capabilities;

* 2 DAPS and CAPC related capabilities are not applicable for RedCap UE;

Similar as what we discussed for CA/DC in [1], it is difficult to clarify this one by one since there are many DAPS/CAPC related capabilities. Rapporteur would suggest to add the clarification in general part, e.g. RedCap specific section that “All UE capabilities related to DAPS and CAPC are not applicable for RedCap UE.”;

**Companies are invited to provide your view on whether it is ok to add the clarification in RedCap specific section that “All UE capabilities related to DAPS and CAPC are not applicable for RedCap UE.”.**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Agree or not** | **Comments, if any** |
| Huawei, HiSilicon | Agree |  |
| Apple | Agree |  |
| OPPO | Agree |  |
| Futurewei | Agree |  |
| CATT | Agree |  |
| vivo | Agree |  |

**Note: the changes on RedCap specific section are shown in section 3.9.**

## How to capture the agreements on IAB related capabilities;

* 4 From RAN2 perspective, IAB related capabilities are not applicable for RedCap UE, i.e. the RedCap UE is not expected to act as IAB node;

Similar as what we discussed for CA/DC in [1], it is difficult to clarify this one by one since there are many IAB related capabilities. Rapporteur would suggest to add the clarification in general part, e.g. RedCap specific section that “All UE capabilities related to IAB are not applicable for RedCap UE.” Or exactly same as agreements “the RedCap UE is not expected to act as IAB node”;

**Companies are invited to provide your view on whether it is ok to add the clarification in RedCap specific section?**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Agree or not** | **Comments, if any** |
| Huawei, HiSilicon | Agree |  |
| Apple | Agree |  |
| OPPO | Agree |  |
| Futurewei | Agree |  |
| CATT | Agree |  |
| Samsung | Agree |  |
| vivo | Agree |  |

**If answer is yes, which option is preferred?**

**Option 1:** All UE capabilities related to IAB are not applicable for RedCap UE.

**Option 2:** the RedCap UE is not expected to act as IAB node

**Other options?**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Option 1, 2, ?** | **Comments, if any** |
| Huawei, HiSilicon | Option 1 | No strong view, since option 1 is clear enough. Or, we could say “All UE capabilities related to IAB are not applicable for RedCap UE (i.e. the RedCap UE is not expected to act as IAB node).”  Minor wording clarification: “IAB node” should be “IAB-MT” since IAB-DU is more like the NW functionality rather than UE functionality. |
| Apple | No strong view. |  |
| OPPO | Option 1/2 | No strong view. |
| Futurewei | Option 1 | (No need to change Option 1, but) just want to clarify that “All UE capabilities related to IAB” refers to those UE capabilities that are unique for IAB-MT, such as those UE capabilities defined in 4.2.15.2 – 4.2.15.9 of TS 38.306, not including those basic UE capabilities (as an IAB-MT) that are even applicable to RedCap UEs. For example, 4.2.15.1 of TS 38.306 includes some basic UE capabilities that are also applicable to RedCap UEs.  The proposed language for Q3.9 is softer than this (i.e., without “All”) and therefore should be OK. |
| CATT | Option 1/2 | Also agree with the merged version from Huawei, but “IAB-node” is ok. |
| Samsung | Either |  |
| vivo | Option 1 | Slightly prefer option 1. Option 2 is also acceptable. |

**Note: the changes on RedCap specific section are shown in section 3.9.**

## How to capture Maximum BW;

As discussed in [2],

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| 21 companies provided inputs to this discussion point.   * **Option 2)** to add “For FR1 RedCap UE, the bit which indicates 20MHz shall be set to 1, and the bits which indicate 25, 30, 40, 50, 60 and 80MHz are ignored. For FR2 RedCap UE, the bit which indicates 100MHz shall be set to 1, and the third / rightmost bit is ignored.” and “channelBWs-DL-v1590 is not applicable to RedCap UE.” for field description of existing fields “channelBWs-DL” and “channelBWs-UL” and add “This capability is not applicable to RedCap UE.” for field description of existing fields “channelBW-90mhz”;   The option 2 is supported by 10 companies (Intel, Spreadtrum, ZTE, CMCC, vivo, Ericsson, NEC, LGE, Nokia, OPPO)   * **Option 3)** to create a new section in 38.306 to capture the maximum UE bandwidth for RedCap UE   The option 3 is supported by 9 companies (Huawei, Qualcomm, Futurewei, Sequans, CATT, Turkcell, MediaTek, Nokia, Telecom Italia)   * **Compromised solution** to combine option 2 and 3, for new section capture “For RedCap UE, the maximum bandwidth on FR1 is 20 MHz, and the maximum bandwidth on FR2 is 100 MHz.””   The compromised solution is supported by 3 companies (Huawei, Sequans, Ericsson )  Ericsson commented that “Regarding the suggested text, it is actually not correct as RedCap UE should not indicate “1” for channels which do not support 20 MHz bandwidth. Thus, perhaps the wording in the description should be changed to something like “RedCap UEs shall support the maximum channel bandwidth defined for the respective band but no more than 20 MHz.”; Rapporteur tends to agree with this, and would suggest to change option 2 to   * **Option 2)** to add “RedCap UEs shall support the maximum channel bandwidth defined for the respective band but no more than 20 MHz for FR1 and no more than 100 Mhz for FR2.~~For FR1 RedCap UE, the bit which indicates 20MHz shall be set to 1, and the bits which indicate 25, 30, 40, 50, 60 and 80MHz are ignored. For FR2 RedCap UE, the bit which indicates 100MHz shall be set to 1, and the third / rightmost bit is ignored.~~” and “channelBWs-DL-v1590 is not applicable to RedCap UE.” for field description of existing fields “channelBWs-DL” and “channelBWs-UL” and add “This capability is not applicable to RedCap UE.” for field description of existing fields “channelBW-90mhz”;   **Rapporteur**: Rapporteur consider Huawei’s WF is the good compromise that can resolve most companies’ concern. In addition, Ericsson’s wording looks good. Therefore Rapporteur would suggest to agree:  **Proposal 9.** **[To discuss]** Whether to capture Maximum BW limitation for RedCap UE in existing field description, and add the clarification in the new section for the definition of RedCap UE:  **Proposal 9.1.** To create a new section in 38.306 to capture the maximum UE bandwidth for RedCap UE as“For RedCap UE, the maximum bandwidth on FR1 is 20 MHz, and the maximum bandwidth on FR2 is 100 MHz.”  **Proposal 9.2.** to add “RedCap UEs shall support the maximum channel bandwidth defined for the respective band but no more than 20 MHz for FR1 and no more than 100 Mhz for FR2.” and “channelBWs-DL-v1590 is not applicable to RedCap UE.” for field description of existing fields “channelBWs-DL” and “channelBWs-UL” and add “This capability is not applicable to RedCap UE.” for field description of existing fields “channelBW-90mhz”; |

Rapporteur suggest to change proposal 9.2 a bit as

**Proposal 9.2.** to add “RedCap UEs shall support the maximum channel bandwidth defined for the respective band up to ~~but no more than~~ 20 MHz for FR1 and up to ~~no more than~~ 100 Mhz for FR2.” and “channelBWs-DL-v1590 is not applicable to RedCap UEs.” for field description of existing fields “channelBWs-DL” and “channelBWs-UL” and add “This capability is not applicable to RedCap UEs.” for field description of existing fields “channelBW-90mhz”;

**Companies are invited to provide your view on whether the compromised solution in proposal 9, 9.1 and updated 9.2 is acceptable?**

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| --- | --- | --- |
| **Company’s name** | **Agree or not** | **Comments, if any** |
| Huawei, HiSilicon | Agree with the intention to capture both.  But not fine with 9.2 wording. | “RedCap UEs shall support the maximum channel bandwidth defined for the respective band up to 20 MHz for FR1 and up to 100 Mhz for FR2”  In the above wording, it has to be clarified on the meaning “shall support”. As agreed in R1, 20Mhz for FR1 and 100Mhz for FR2 shall be set to 1. This is different with the 5/10/15 MHz cases. Therefore, we have to specifically clarified the 20MHz and 100MHz is mandatory supported (cannot be set to 0). It is not possible for RedCap UE not supporting “20Mhz for FR1 and 100Mhz for FR2”. The R1 agreement “*For RedCap UEs in FR1, The baseline UE bandwidth capability is 20 MHz, which can be assumed during the initial access procedure.*” is clear that RedCap not supporting “20Mhz for FR1 and 100Mhz for FR2” cannot work during initial access.  The wording in P9.2 is not acceptable without the clarification that “For FR1 RedCap UE, the bit which indicates 20MHz shall be set to 1. For FR2 RedCap UE, the bit which indicates 100MHz shall be set to 1”. |
| OPPO | Agree |  |
| Futurewei | Agree but | But also agree with Huawei that the description should be consist with the current RAN1 agreement without ambiguity. We can also consider an earlier version of option 2 as follows:  **Option 2)** to add “RedCap UEs shall support the maximum channel bandwidth defined for the respective band but no more than 20 MHz for FR1 and no more than 100 Mhz for FR2. For FR1 RedCap UE, the bit which indicates 20MHz shall be set to 1, and the bits which indicate 25, 30, 40, 50, 60 and 80MHz are ignored. For FR2 RedCap UE, the bit which indicates 100MHz shall be set to 1, and the third / rightmost bit is ignored.” and “channelBWs-DL-v1590 is not applicable to RedCap UE.” for field description of existing fields “channelBWs-DL” and “channelBWs-UL” and add “This capability is not applicable to RedCap UE.” for field description of existing fields “channelBW-90mhz”; |
| CATT | Agree | It is clear enough, when considering the context description. |
| Samsung | Agree | We support rapporteur's compromise and update. |
| vivo | Agree with comments | Our understanding is that original Option 2 is more accuracy.  Besides, we need also need to capture the mandatory supported BW: “For RedCap UE, the maximum bandwidth on FR1 is 20 MHz, and the maximum bandwidth on FR2 is 100 MHz.” |

**Note: the changes on RedCap specific section (proposal 9.1) are shown in section 3.9.**

#### TS38.306 TP on Maximum Bandwidth (proposal 9.2):

#### 4.2.7.2 *BandNR parameters*

/\*\*\* omitted unrelated parts\*\*\*/

| **Definitions for parameters** | **Per** | **M** | **FDD-TDD**  **DIFF** | **FR1-FR2**  **DIFF** |
| --- | --- | --- | --- | --- |
| ***channelBWs-DL***  Indicates for each subcarrier spacing the UE supported channel bandwidths. Absence of the *channelBWs-DL* (without suffix) for a band or absence of specific scs-XXkHz entry for a supported subcarrier spacing means that the UE supports the channel bandwidths among [5, 10, 15, 20, 25, 30, 40, 50, 60, 80, 100] and [50, 100, 200] that were defined in clause 5.3.5 of TS 38.101-1 version 15.7.0 [2] and TS 38.101-2 version 15.7.0 [3] for the given band or the specific SCS entry. For IAB-MT, to determine whether the IAB-MT supports a channel bandwidth of 100 MHz, the network checks c*hannelBW-DL-IAB-r16*.  For FR1, the bits in *channelBWs-DL* (without suffix) starting from the leading / leftmost bit indicate 5, 10, 15, 20, 25, 30, 40, 50, 60 and 80MHz. For FR2, the bits in *channelBWs-DL* (without suffix) starting from the leading / leftmost bit indicate 50, 100 and 200MHz. The third / rightmost bit (for 200MHz) shall be set to 1. For IAB-MT the third / rightmost bit (for 200MHz) is ignored. To determine whether the IAB-MT supports a channel bandwidth of 200 MHz, the network checks *channelBW-DL-IAB-r16*.  For FR1, the leading/leftmost bit in *channelBWs-DL-v1590* indicates 70MHz, the second leftmost bit indicates 45MHz, the third leftmost bit indicates 35MHz and all the remaining bits in *channelBWs-DL-v1590* shall be set to 0.  RedCap UEs shall support the maximum channel bandwidth defined for the respective band up to 20 MHz for FR1 and up to 100 Mhz for FR2. *channelBWs-DL-v1590* is not applicable to RedCap UEs.  NOTE: To determine whether the UE supports a specific SCS for a given band, the network validates the *supportedSubCarrierSpacingDL* and the *scs-60kHz*. To determine whether the UE supports a channel bandwidth of 90 MHz, the network may ignore this capability and validate instead the *channelBW-90mhz* and the *supportedBandwidthCombinationSet*. For serving cell(s) with other channel bandwidths the network validates the *channelBWs-DL*, the *supportedBandwidthCombinationSet*, the *supportedBandwidthCombinationSetIntraENDC*, the *asymmetricBandwidthCombinationSet* (for a band supporting asymmetric channel bandwidth as defined in clause 5.3.6 of TS 38.101-1 [2]) and *supportedBandwidthDL*. | Band | Yes | N/A | N/A |
| ***channelBWs-UL***  Indicates for each subcarrier spacing the UE supported channel bandwidths.  Absence of the *channelBWs-UL* (without suffix) for a band or absence of specific scs-XXkHz entry for a supported subcarrier spacing means that the UE supports the channel bandwidths among [5, 10, 15, 20, 25, 30, 40, 50, 60, 80, 100] and [50, 100, 200] that were defined in clause 5.3.5 of TS 38.101-1 version 15.7.0 [2] and TS 38.101-2 version 15.7.0 [3] for the given band or the specific SCS entry. For IAB-MT, to determine whether the IAB-MT supports a channel bandwidth of 100 MHz, the network checks *channelBW-UL-IAB-r16*.  For FR1, the bits in *channelBWs-UL* (without suffix) starting from the leading / leftmost bit indicate 5, 10, 15, 20, 25, 30, 40, 50, 60 and 80MHz. For FR2, the bits in *channelBWs-UL* (without suffix) starting from the leading / leftmost bit indicate 50, 100 and 200MHz. The third / rightmost bit (for 200MHz) shall be set to 1. For IAB-MT the third / rightmost bit (for 200MHz) is ignored. To determine whether the IAB-MT supports a channel bandwidth of 200 MHz, the network checks *channelBW-UL-IAB-r16*.  For FR1, the leading/leftmost bit in *channelBWs-UL-v1590* indicates 70 MHz, the second leftmost bit indicates 45MHz, the third leftmost bit indicates 35MHz and all the remaining bits in *channelBWs-UL-v1590* shall be set to 0.  RedCap UEs shall support the maximum channel bandwidth defined for the respective band up to 20 MHz for FR1 and up to 100 Mhz for FR2. *channelBWs-UL-v1590* is not applicable to RedCap UEs.  NOTE: To determine whether the UE supports a specific SCS for a given band, the network validates the *supportedSubCarrierSpacingUL* and the *scs-60kHz*. To determine whether the UE supports a channel bandwidth of 90 MHz the network may ignore this capability and validate instead the *channelBW-90mhz* and the *supportedBandwidthCombiantionSet*. For serving cell(s) with other channel bandwidths the network validates the *channelBWs-UL*, the *supportedBandwidthCombinationSet*, the *supportedBandwidthCombinationSetIntraENDC*, the *asymmetricBandwidthCombinationSet* (for a band supporting asymmetric channel bandwidth as defined in clause 5.3.6 of TS 38.101-1 [2]) and *supportedBandwidthUL*. | Band | Yes | N/A | N/A |
| ***channelBW-DL-IAB-r16***  Indicates whether the IAB-MT supports channel bandwidth of 100 MHz for a given SCS in FR1 for DL or whether the IAB-MT supports channel bandwidth of 200 MHz for a given SCS in FR2 for DL. | Band | No | N/A | N/A |
| ***channelBW-UL-IAB-r16***  Indicates whether the IAB-MT supports channel bandwidth of 100 MHz for a given SCS in FR1 for UL or whether the IAB-MT supports channel bandwidth of 200 MHz for a given SCS in FR2 for UL. | Band | No | N/A | N/A |

#### 4.2.7.6 *FeatureSetDownlinkPerCC* parameters

| **Definitions for parameters** | **Per** | **M** | **FDD-TDD**  **DIFF** | **FR1-FR2**  **DIFF** |
| --- | --- | --- | --- | --- |
| ***channelBW-90mhz***  Indicates whether the UE supports the channel bandwidth of 90 MHz.  For FR1, the UE shall indicate support according to TS 38.101-1 [2], Table 5.3.5-1. This capability is not applicable to RedCap UEs. | FSPC | CY | N/A | FR1 only |
| ***maxNumberMIMO-LayersPDSCH***  Defines the maximum number of spatial multiplexing layer(s) supported by the UE for DL reception. For single CC standalone NR, it is mandatory with capability signaling to support at least 4 MIMO layers in the bands where 4Rx is specified as mandatory for the given UE and at least 2 MIMO layers in FR2. If absent, the UE does not support MIMO on this carrier. | FSPC | CY | N/A | N/A |

Note: Rapporteur considers the changes in 4.2.7.6 on *channleBW-90mhz* is not needed since the RedCap UE cannot support CA/DC and therefore *FeatureSetDownlinkPerCC* parameter shall not be included.

**Companies are invited to provide your view on the TP for maximum bandwidth shown as above (proposal 9.2). Also please indicate if anything is missing. Companies that do not agree the TP should provide the alternative TP or suggested change.**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Agree or not** | **Comments, if any** |
| Huawei, HiSilicon | See comments | The intention is fine. But:  1: The TP is only agreeable with the condition that we also capture “For RedCap UE, the maximum bandwidth on FR1 is 20 MHz, and the maximum bandwidth on FR2 is 100 MHz.” (Proposal 9.1) in the RedCap specific section.  2: *channleBW-90mhz* should also be clarified. Actually, UE not supporting CA/DC also reports the FeatureSetDownlinkPerCC, which is the only way to report DL MIMO layer capability.  3: “supportedBandwidthDL” in *FeatureSetDownlinkPerCC* and” supportedBandwidthUL” in *FeatureSetUplinkPerCC* should also be clarified using the same sentence, because its description “*When this field is included in a band combination with a single band entry and a single CC entry (i.e. non-CA band combination), the UE shall indicate the maximum channel bandwidth for the band according to TS 38.101-1 [2] and TS 38.101-2 [3].*” is not aligned with what we are trying to clarify for RedCap in channelBWs-DL.  4. Also see our concern on the wording in previous question. |
| OPPO | Agree |  |
| Futurewei | Partially agree | We think it is beneficial to further clarify how various bits in *channelBWs-DL* and  *channelBWs-DL* are treated differently for RedCap UEs than for non-RedCap UEs, as in our response to the previous question. |
| CATT | Agree |  |
| Samsung | Agree |  |
| vivo | Agree | Comments see above Q. |

## How to capture MIMO layer;

As discussed in [2],

|  |
| --- |
| 20 companies provided inputs to this discussion point.   * **Option 1: to add “**RedCap UE supports 1 DL MIMO layer if 1 Rx branch is supported, and 2 DL MIMO layers if 2 Rx branches are supported.” for field description of existing fields “***maxNumberMIMO-LayersPDSCH***”   Option 1 is supported by 3 companies (Intel, Huawei, CMCC ), Sequans, NEC, Telecom Italia, Deutsche Telekom can also accept this.   * **Option 2**: to add “For RedCap UE, if signalled, only 2 MIMO layers can be reported.” for field description of existing fields “***maxNumberMIMO-LayersPDSCH***”;   Option 2 is supported by 4 companies (Spreadtrum, ZTE, Apple, vivo, OPPO )   * **Option 3:** to create a new section in 38.306 to capture the relationship between Rx and MIMO layers;   Option 3 is supported by 12 companies (Qualcomm, vivo, Sequans, Ericsson, CATT, Turkcell, NEC, MediaTek, LGE, Telecom Italia, Nokia, Deutsche Telekom,)  Huawei, ZTE discussed whether “support 1 DL MIMO layer” is same as “not supporting DL MIMO”. This is the main different between option 1 and 2. From Rapporteur perspective, the confusion came from the wording “If absent, the UE does not support MIMO on this carrier.”. The UE should at least support 1 MIMO layer to receive PDSCH. Then we may clarify this in TS38.306, i.e. “If absent, the UE ~~does not~~ support 1 MIMO layer on this carrier.”.. But this is out of RedCap discussion.  Futurewei, Sequans would like to support the scenario that 2Rx with 1 layer, however vivo commented that it has been excluded as clearly described in the WID.  **Rapporteur**: The main question for option 1 and 2 is whether not supporting DL MIMO is same as support 1 DL MIMO layer. This should be confirmed in the meeting. But to be safe, we can follow the WID, i.e. RedCap UE supports 1 DL MIMO layer if 1 Rx branch is supported, and 2 DL MIMO layers if 2 Rx branches are supported. In addition, the situation is similar as 2.2.1 on how to capture maximum BW. We may agree to capture the relationship between Rx and MIMO layer in the new section. And FFS on whether to capture anything in field description of maxNumberMIMO-LayersPDSCH, as commented by Ericsson “if new values are created and existing signaling is not used as-is, then the field description needs to be updated (Option 1).”  **Proposal 11.** **[To discuss]** Whether to create a new section in 38.306 to capture the relationship between Rx and MIMO layers “RedCap UE supports 1 DL MIMO layer if 1 Rx branch is supported, and 2 DL MIMO layers if 2 Rx branches are supported”;  **Proposal 12.** **[FFS]** To discuss in main session whether “support 1 DL MIMO layer” is same as “not supporting DL MIMO”, and whether current field description “If absent, the UE does not support MIMO on this carrier.” in TS38.306 needs to be updated; |

Rapporteur comments:

Proposal 12 is not RedCap specific issue, and therefore should be discussed separately.

There is large support on option 3, i.e. to create a new section in 38.306 to capture the relationship between Rx and MIMO layers “RedCap UE supports 1 DL MIMO layer if 1 Rx branch is supported, and 2 DL MIMO layers if 2 Rx branches are supported”;

Rapporteur would suggest to go with option 3 for now. And may update the field description if new values are created and existing signaling is not used as-is.

**Companies are invited to provide your view on whether the proposal 11 is acceptable**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Agree or not** | **Comments, if any** |
| Huawei, HiSilicon | Agree | Agree with rapporteur to capture option 3 at least as baseline, which means any other additional change can be discussed in next meeting. |
| Apple | Option 3 is ok for us. |  |
| OPPO | Agree |  |
| Futurewei | Disagree but willing to compromise with the majority. | We continue to believe that setting the number of Rx branches to be equal to maxNumberMIMO-LayersPDSCH has a drawback, which is either a RedCap UE equipped with multiple Rx branches will be penalized as being mandated to support DL MIMO with number of layers greater than 1, when the RedCap UE just needs the extra Rx branches for receiver diversity gain to achieve better DL coverage, or the network may be penalized for scheduling a RedCap UE equipped with multiple Rx branches in an overly conservative manner (i.e., applying a margin in the scheduling algorithm to overcome the seemingly lack of receiver diversity) when the RedCap UE doesn’t support DL MIMO and therefore its number of Rx branches is understated by maxNumberMIMO-LayersPDSCH. |
| CATT | Agree |  |
| Samsung | Agree |  |
| vivo | Agree |  |

**Note: the changes on RedCap specific section (proposal 11) are shown in section 3.9.**

## How to capture maximum modulation order;

As discussed in [1]:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 21 companies provided inputs to this discussion point.   * 17 Companies (ZTE, Apple, OPPO, Spreadtrum, Qualcomm, Sierra Wireless, Futurewei, Samsung, Lenovo, KDDI, vivo, Sharp, Xiaomi, CATT, Ericsson, ChinaTelecom, MediaTek) support the suggestion from ZTE as  | **Definitions for parameters** | **Per** | **M** | **FDD-TDD**  **DIFF** | **FR1-FR2**  **DIFF** | | --- | --- | --- | --- | --- | | ***pdsch-256QAM-FR1***  Indicates whether the UE supports 256QAM modulation scheme for PDSCH for FR1 as defined in 7.3.1.2 of TS 38.211 [6].  It is mandatory with capability signaling for non-RedCap UE and optional for RedCap UE. | UE | CY | No | FR1 only |   **Proposal 19.** **[To agree] [TP to TS38.306] to capture maximum modulation order for RedCap UE as, for the field “pdsch-256QAM-FR1”, the value for column “M” should be changed from “Yes” into “CY”, add in the field description “It is mandatory with capability signaling for non-RedCap UE and optional for RedCap UE.”.** |

Rapporteur comments: there is clear majority on this, and therefore Rapporteur would like to check whether the following TP is ok or not.

#### TS38.306 TP on Maximum number of 256QAM

4.2.7.10 *Phy-Parameters*

| **Definitions for parameters** | **Per** | **M** | **FDD-TDD**  **DIFF** | **FR1-FR2**  **DIFF** |
| --- | --- | --- | --- | --- |
| ***pdsch-256QAM-FR1***  Indicates whether the UE supports 256QAM modulation scheme for PDSCH for FR1 as defined in 7.3.1.2 of TS 38.211 [6].  It is mandatory with capability signalling for non-RedCap UEs and optional for RedCap UEs. | UE | CY | No | FR1 only |

**Companies are invited to provide your view on the TP for maximum DL modulation order shown as above. Also please indicate if anything is missing.**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Agree or not** | **Comments, if any** |
| Huawei, HiSilicon | No, but | Even though we still believe it is better to capture it in the RedCap specific section as below, we are fine to compromise to the majority view. Maybe it is also good to capture this in both exiting field description and Redcap specific section. |
| OPPO | Agree |  |
| Futurewei | Agree |  |
| CATT | Agree |  |
| Samsung | Agree |  |
| vivo | Agree | Similar view as Huawei, whether to have a separate section for RedCap in TS 38.306 could be discussed in general for all siganling. |

## How to capture CA, DC;

In last meeting, RAN2 agreed that “NE-DC, and (NG)EN-DC are not supported by RedCap UE; ”, therefore it can be covered by MR-DC case.

As discussed in [1]:

|  |
| --- |
| 20 companies provided inputs to this discussion point.   * 14 companies (Intel, ZTE, Apple, Spreadtrum, Sierra Wireless, Futurewei, Samsung, Lenovo, Sharp, Xiaomi, Ericsson, ChinaTelecom, LGE, MediaTek,) agree the idea from Rapporteur. ZTE commented that the sentence could be changed to “All UE capabilities related to CA and MR-DC are not applicable for RedCap UE.”. * 8 companies (Qualcomm, Futurewei, Samsung, vivo, MediaTek, Xiaomi, CATT, Ericsson) would like to introduce the definition of RedCap UE instead of including everything in the field description. * 4 companies (Sierra Wireless, Futurewei, vivo, Xiaomi ) would like to clarify BW, QAM, etc together. Rapporteur consider this is also related to discussion in previous sections.   **Proposal 20.** **[To agree] [14/20] [TP to TS38.306] Add the clarification “All UE capabilities related to CA and MR-DC are not applicable for RedCap UE.”in RedCap specific section; FFS on the definition of RedCap UE, and whether to capture other restrictions together, e.g. BW, RX, MIMO, QAM, etc.** |

**Companies are invited to provide your view on whether it is ok to add the clarification in RedCap specific section that All UE capabilities related to CA and MR-DC are not applicable for RedCap UE.”.**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Agree or not** | **Comments, if any** |
| Huawei, HiSilicon | Agree |  |
| OPPO | Agree |  |
| Futurewei | Agree |  |
| CATT | Agree |  |
| Samsung | Agree |  |
| vivo | Agree |  |

**Note: the changes on RedCap specific section are shown in section 3.9.**

## TP on RedCap specific section

A TP on RedCap specific section is shown as below to capture DAPS/CAPC, IAB, Maximum BW, Rx/MIMO and CA/DC:

#### TS38.306 TP on RedCap specific section

4.2.xx RedCap parameters

RedCap UE is the UE with reduced capability:

* The maximum bandwidth up to 20 MHz for FR1, and up to 100 MHz for FR2;
* 1 DL MIMO layer if 1 Rx branch is supported, and 2 DL MIMO layers if 2 Rx branches are supported;
* CA, MR-DC, DAPS, CPC and IAB 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, unless indicated otherwise.

**Companies are invited to provide your view on the TP for RedCap specific section shown as above. Also please indicate if anything is missing.**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Agree or not** | **Comments, if any** |
| Huawei, HiSilicon | Yes, but | One typo maybe: It seems there is no “CPC” in our agreement. Is it CAPC? But, it seems the terminology should be “Conditional PSCell Addition and Change->CPAC”, rather than CAPC.   * *DAPS and CAPC related capabilities are not applicable for RedCap UE; [8/20] FFS on CHO. FFS on how to capture this in the specification;*   The wording itself is general OK. The current formulation is somehow aligned with RAN1 agreement. However, there seems missing the “RedCap UE” terminology definition in the section 3.1 of TS 38.306. Therefore, we should also add one sentence in section 3.1, such as below  “  3.1 Definitions  **RedCap UE:** the UE mandatorily supporting maximum bandwidth 20MHz in FR1 and 100MHz in FR2, and other reduced capabilities specified in sub-clause 4.2.x.x.  ”  One minor wording comment on “remain applicable for RedCap UEs”. Maybe it is better to use “remain applicable for RedCap UEs same as non-RedCap UEs”. This is not just to clarify its applicability but also to clarify the “mandatory or optional” remain same as legacy UE. |
| OPPO | Agree with comments | Agree with Huawei’s comment to change “CPC” into “CPAC”. |
| Futurewei | Agree | Also agree with Huawei on changing “CPC” to “CPAC”. |
| Samsung | Agree | Agree to use "CPAC" |
| vivo | Agree | Whether we need to have a definition of RedCap UE? |

# Summary report and proposals

Aiming to help with the meeting discussion/progress, the proposals are categorized starting with:

* [To agree] when there is large support and hence proposed for easy agreement.
* [To discuss] when there is substantial level of support and agreement may be possible.
* [FFS] when there is low support or companies propose new solutions or options to possibly consider further e.g. if there is sufficient support (understanding that these topic have not been discussed by all companies when providing their views in the different discussion points).

The proposals also start with a number: for the format [x], ‘x’ represents the number of supportive companies (i.e. these solutions are marked as FFS as the proposed solutions were not discussed by all companies) and, for the format [x/y], ‘x’ represents the number of supportive companies, and (y-x) the number of companies with different view.

The observations captured are the following:

**Observation 1.** xxxx.

The proposals captured are the following:

**Proposal 1.** **[To agree]**

The following list shows the proposals above organized based on the suggested priority aiming to help during its meeting discussion:

**Proposals for easy agreement**

**Proposal 1.** **[To agree]**

**Proposals for discussion (1st priority) or to be captured as FFS**

**Proposal 6.** **[To discuss]**

**Proposals for discussion (2nd priority) or to be captured as FFS**

xxx

# Reference

1. R2-2107676 Email discussion report on [105][RedCap] Capabilities (Intel) Intel Corporation
2. R2-2108891 [offline 109] RedCap capabilities Intel
3. R2-2109129 [offline 109] RedCap capabilities - second round Intel
4. Draft TS 38.306 g60-v2
5. Draft TS 38.331 g60
6. R2-2107208 Definition and reduced capabilities for RedCap UE Huawei, HiSilicon