3GPP TSG RAN WG2 Meeting #115-e R2-17xxxxx

**Electronic meeting, 16th-27th August 2021**

**Agenda item:** x.x.x

**Source:** Intel Corporation

**Title:** Report of email discussion [Post114-e][105][RedCap] Capabilities (Intel)

**Document for:**  Discussion and decision

# Introduction

This is the email discussion report for following email discussion:

* [Post114-e][105][RedCap] Capabilities (Intel)

Scope: Discuss which higher layer capabilities are not applicable for RedCap UEs and how to reflect the handling of RedCap specific capabilities (e.g. Maximum BW, Max Rx, MIMO-Layer, 256QAM, CA/DC, HD-FDD, etc.). Can take the principles in P3.x in R2-2106528 as an initial guideline.

Intended outcome: Report (it could also result in a draft 38.306 CR)

Deadline: August 6th, 0900 UTC

**Note**: silent period is July 5-30

Rapporteur would like to split the discussion in three phases:

**Phase 1**: To discuss which higher layer capabilities are not applicable for RedCap UEs; The **deadline for this 1st phase** of email discussion is **Monday June 28st, 0900 UTC.**

**Phase 2**: To discuss how to reflect the handling of RedCap specific capabilities (e.g. Maximum BW, Max Rx, MIMO-Layer, 256QAM, CA/DC, HD-FDD, etc., and the higher layer capabilities based on outcome from phase 1); The **deadline for this 2nd phase** of email discussion is **Monday Aug 2nd , 0900 UTC.**

**Phase 3**: To check the proposals from Rapporteur and the draft CR(s); The **deadline for this 3rd phase** of email discussion is **Friday Aug 6th , 0900 UTC.**

# Phase 1- Which higher layer capabilities are not applicable for RedCap UEs

At RAN2#114-e, based on [1], [2] and [3], RAN2 discussed RedCap UE capabilities and agreed:

Working assumption:

1. Extend UE-NR-Capability using NCE to capture RedCap capabilities

Agreements:

1. We will continue the discussion on which capability are applicable to RedCap UE (FFS if we need to have an exhaustive check)

Agreements online:

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 appliable for RedCap UE, we clarify in the definitions for parameters in TS38.306, the value or feature is not applicable for RedCap UE

Based on [5], CA and DC are not applied for RedCap UE.

* Specify definition of one RedCap UE type including capabilities for RedCap UE identification and for constraining the use of those RedCap capabilities only for RedCap UEs, and preventing RedCap UEs from using capabilities not intended for RedCap UEs including at least carrier aggregation, dual connectivity and wider bandwidths. [RAN2, RAN1]

Based on [6], RAN2 discussed higher layer capabilities, and agreed:

Agreements via email - from offline [107]

1. Capture ‘maximum number of DRBs mandatory supported’ in the TR as one L2 capability which can be reduced for RedCap UEs.

Agreements online:

1. Capture the following in the TR on reducing total layer-2 buffer size for RedCap UEs:

“According to the calculation in TS 38.306, with peak data rate reductions, L2 buffer requirements for RedCap UEs are implicitly reduced accordingly. The need for further reduction compared to calculation in TS 38.306 needs more discussion”.

1. Capture ‘18-bit SN for PDCP and RLC AM’ in the TR as one L2 capability which can be reduced for RedCap UEs if clear benefit is identified.
2. Capture in the TR that the gain to reduce RRC processing delay needs further discussion.

The following was captured in the TR [4]:

|  |
| --- |
| The following UE complexity reduction techniques for higher layers have been discussed in RAN2:  - Reduction of the maximum number of DRBs which UE needs to mandatorily support.  - Reduction of L2 buffer size. According to the calculation in TS 38.306, with peak data rate reductions, L2 buffer requirements for RedCap UEs are implicitly reduced accordingly. Benefits and feasibility of further reduction requires evaluation in normative phase if it is to be considered.  - SN in PDCP and RLC is 18-bits, and the size could be reduced depending on which features RedCap UEs support, if a clear benefit in such reduction is identified.  - The gain of relaxing RRC processing delay requirements was not studied and requires further evaluation in normative phase if it is to be considered.  These UE complexity reduction techniques for higher layers have not been explicit objectives during the study and would require further evaluation during the normative phase if they are to be considered. |

At RAN2#114-e, companies had the following proposals on higher layer capabilities:

|  |  |  |
| --- | --- | --- |
| Tdoc number | Company | Related proposals and views |
| R2-2105136 | Apple | **Proposal 1: The maximum number of DRBs supported is a mandatory with signaling capability and is provided as part of UE capability for RedCap devices. Range is FFS**  **Proposal 2: The support of 18-bit SN for PDCP is optional with capability signaling for RedCap UEs.**  **Proposal 3: The support of 18-bit SN for RLC AM mode is optional with capability signaling for RedCap UEs.**  **Proposal 4: RRC processing delay requirements for RedCap UEs can be different from legacy NR UEs. FFS on the actual values.** |
| R2-2105539 | Spreadtrum | **Proposal 1: Support scalingFactor report for REDCAP UE, considering some additional smaller values or the REDCAP UE specific values to match the requirement of REDCAP UE use case better.** |
| R2-2105634 | Huawei | **Proposal 6: Consider to reduce the number of DRBs mandatorily supported by RedCap UEs.**  **Proposal 7: Consider to reduce the length of PDCP and RLC AM sequence number to be mandatorily supported for RedCap UE (e.g. mandatory 12-bit SN).**  **Proposal 8: Do not consider to further reduce the L2 buffer size calculated in TS 38.306.**  **Proposal 9: Do not consider to relax the RRC processing delay for RedCap UEs.** |

In addition, one company commented that “We could further discuss it during WI phase, e.g. DRX numbers or L2 buffer size.”.

1. Following higher layer capabilities were proposed as not applicable for RedCap UE or that some change are needed for RedCap UE;
2. Maximum number of DRBs (8 DRBs, Mandatory without UE capability signalling for non-RedCap UE); FFS on number;
3. PDCP 18bits SN (Mandatory without UE capability signalling for non-RedCap UE); FFS on mandatory SN;
4. RLC AM with 18bits SN (Mandatory without UE capability signalling for non-RedCap UE); FFS on mandatory SN;
5. L2 buffer size in TS38.306; FFS on the number;
6. RRC processing delay; FFS on the number;
7. Introduce smaller scalingFactor for RedCap UE;
8. DRX number? (Rapporteur, it is unclear whether it means the change on existing DRX number or eDRX for RedCap UE)

Based on working assumption “*by default, all non-RedCap UE capabilities are applicable for RedCap UE*”, Rapporteur believes that we do not need to go through higher layer capabilities one by one in this email discussion except those have been proposed by companies in previous meeting (above 7 higher layer capabilities). Instead, companies are invited to provide view on what higher layer capabilities are not applicable for RedCap UE.

1. Companies are invited to provide the view on above 7 higher layer capabilities. Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)

**Discussion point 1.1: Should Maximum number of DRBs to be optional for RedCap UE?** **Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)**

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| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | Yes | We are fine to make Maximum 8 DRBs as optional feature for RedCap UE; |
| Qualcomm | Yes | We think the current requirement of maximum 8 DRBs can be relaxed for RedCap UEs.  Justifications: Each DRB requires a separate instance of PDCP/RLC. The max number of DRBs hence has a direct impact on UE’s memory size. Reducing this requirement can help reduce RedCap UE’s cost and simplify RedCap UE’s implementation.  Value for Redcap: RedCap UEs are only required to support a maximum of 4 DRBs. |
| Spreadtrum | Yes | We are ok to reduce the Maximum DRBs number for Redcap UE. |
| Lenovo | Yes | We are fine to reduce the Maximum DRB number for RedCap UE. |
| Huawei, HiSilicon | Yes | First, we’d like to clarify the current spec.   |  |  |  |  | | --- | --- | --- | --- | | |  |  |  | | --- | --- | --- | | #DRBs | The number of DRBs that a UE shall support. | 16 per UE.  NOTE 1  NOTE 3 |   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.  NOTE 3: This requirement is applicable in NR SA, NR-DC and NE-DC. |   For legacy UE, the mandatory maximum number of DRBs is 16 rather than 8. Since there will no DRBs configured with PDCP duplication for RedCap, NOTE1 does not apply to RedCap UE.  As mentioned by Intel and QC, it is beneficial to relax the max number of DRBs for RedCap UE to reduce the memory size. Therefore, we support to reduce the supported max number of DRBs for RedCap UE.  Value for RedCap: The max number of DRBs that a RedCap UE shall support be 8. (i.e. reduced from 16->8). |
| Futurewei | Yes but… | First, we should specify a number of DRBs that all RedCap UEs shall support without a need for signaling. Supporting such specified number of DRBs is mandatory for all RedCap UEs, not optional. Hence, this is the minimum number of DRBs that all RedCap UEs shall support. In other words, if a gNB doesn’t receive additional UE capabilities information from a RedCap UE indicating that the UE supports more than the mandatory number of DRBs, this is the maximum number of DRBs that the gNB can configure for the UE.  Second, we agree with Huawei that the number of DRBs that a (non-RedCap) UE shall support is currently 16. We agree with companies that such number should be reduced for RedCap UEs. We are fine with either 4 or 8.  Third, recommend that we drop the word “maximum” and use the same expression as in the legacy text to avoid potential confusion of whether this number is a maximum number or a minimum number. |
| Ericsson | No | Agree with Futurewei that the formulation is not accurate and if the number is reduced, the number of supported DRBs shall be specified for RedCap UEs and this should be mandatory for all RedCap UEs.  However, we think this cost reduction technique is not within the scope of the WI. |
| Samsung | Yes | Agree with Huawei for the current specification, and we are fine to reduce it to 8, given the reduced bandwidth. |

**Discussion point 1.2: Should PDCP 18bits SN be optional for RedCap UE?** **Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)**

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | No | We do not see the clear motivation to make it different from non-RedCap UEs. 18 bits SN is not needed for RedCap UE, but do not see what additional gain we can get by not supporting this. |
| Qualcomm | Yes | We think the mandatory length of PDCP SN field can be reduced from 18 bits to 12 bits for RedCap UEs. 18 bit SN field can be optional for RedCap UEs.  Justifications: buffer size required by PDCP/RLC depends on the width of the sliding window protocol, which in turn depends on the length of the sequence number (SN) field in their headers. For example, in RLC AM mode, the sliding window size is 2,048B when a 12 bit SN is used and 131,072B when 18 bit SN is used. On the other hand, RedCap UEs typically do not run high-throughput applications. Reducing the length of the SN field from 18 bits to 12 bits hence would not have much impact on RedCap UEs’ performance.  Value for RedCap: 12-bit mandatory; 18-bit optional. |
| Spreadtrum | Yes | We are ok for PDCP 18bits SN optional for RedCap UE. Considering the smaller maximum data rate requirement and cost reduction requirement of Redcap UE, we are also open for smaller SN values. |
| Lenovo | Yes | For RedCap UE, PDCP 18bits could be optional. We prefer a smaller value for PDCP SN based on RedCap UE application. |
| Huawei, HiSilicon | Yes | First, 18bits is definitely not necessary for RedCap.  Larger PDCP SN size will result in larger reordering window. Reducing the PDCP/RLC SN size is one quite efficient manner to reduce the higher layer memory size.  Value for RedCap: to use 12bits as mandatory, FFS for 18bits as optional or not applicable. |
| Futurewei | Yes | First, we agree to supporting PDCP 18bits SN being optional for RedCap UEs.  Second, we should make supporting PDCP 12bits SN mandatory for RedCap UEs without a need for signaling. Hence, a *longSN* parameter, instead of the *shortSN* parameter, is needed for RedCap UEs. |
| Ericsson | No | Agree with Intel |
| Samsung | No | We think the gain by reducing the SN size (including the example from Huawei) would be indeed marginal, so no need to make the current size as optional. |

**Discussion point 1.3: Should RLC AM 18bits SN be optional for RedCap UE?** **Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)**

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | No | We do not see the clear motivation to make it different from non-RedCap UEs. 18 bits SN is not needed for RedCap UE, but do not see what additional gain we can get by not supporting this. |
| Qualcomm | Yes | Please see our comment to Discussion Point 1.2 |
| Spreadtrum | Yes | Please refer the comments in Discussion point 1.2 |
| Lenovo | Yes | The same view as in Point1.2. |
| Huawei, HiSilicon | Yes | See our comments above |
| Futurewei | Yes | First, we agree to supporting RLC AM 18bits SN being optional for RedCap UEs.  Second, we should make supporting RLC AM 12bits SN mandatory for RedCap UEs without a need for signaling. Hence, a *am-WithLongSN* parameter, instead of the *am-WithShortSN* parameter, is needed for RedCap UEs. |
| Ericsson | No | Agree with Intel |
| Samsung | No | Same answer as in 1.2 |

**Discussion point 1.4: Should L2 buffer size defined in TS38.306 be changed for RedCap UE?** **Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)**

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | No | We do not see the clear motivation to make it different from non-RedCap UEs. L2 buffer is reduced implicitly if peak data rate is reduced; |
| Qualcomm | Yes | We think reducing the requirement on the total L2 buffer size can help reduce memory size, and hence cost, of RedCap UEs.  Justifications: Although the total L2 buffer size of a RedCap UE scales down with its lower peak data rate*,* the requirement for L2 buffer size according to the current spec can still be large for low-cost devices. For example, if we assume the peak data rate for wearables are 150/50 Mbps on DL/UL and the RLC RTT is 50ms for FR1, the required total layer-2 buffer size is 1.25 MB. This is relatively large for some RedCap UEs (e.g. wearables), whose total memory typically is only a few MBs but that has to be shared among OS, apps, and other run-time procedures. On the other hand, our studies have found that good throughput can still be achieved when actual L2 buffer size is smaller than the theoretical value required by the spec, especially when data is not very bursty. Therefore, we think it is beneficial to allow RedCap UEs to choose their own preferred total layer-2 buffer size and signal that as a UE capability to network.  Value: introduce a scaling factor, which may take values of 0.25x, 0.5x, 0.75x, 1.0x, for the total L2 buffer size. |
| Spreadtrum | With comments | We agree with Qualcomm on the analysis of reducing the requirement on the total L2 buffer size for redcap UE, but we think we can keep L2 buffer size definition and equations in TS 38.306; and for the approximate maximum data rate for RedCap UE, we can follow the formula defined in TS 38.306.  However, for higher layer parameter *scalingFactor* in maximum data rate formula, we propose to change the values of *scalingFactor* for RedCap. The related motivation details is explained in the following **Discussion point 1.6**. |
| Lenovo | See comments | For redcap UE, the L2 buffer size defined in TS38.306 may be kept but with a smaller *scalingFactor.* |
| Huawei, HiSilicon | No | Since the bandwidth and maximum modulation order of RedCap UE has been reduced, the DL/UL peak data and the L2 buffer size of RedCap UE also will be reduced accordingly. The motivation of further reducing this value is not clear. |
| Futurewei | Probably no | We don’t see a strong reason for changing the current way for deriving the total L2 buffer size, except that processing time relaxation, on which we have not drawn a conclusion yet, may have a small (but possibly negligible) impact on the RLC RTT. |
| Ericsson | No | The existing calculation in TS 38.306 should be re-used, agree with Huawei comments. |
| Samsung | No | The maximum data rate would be bounded by the reduced capability (bandwidth) anyway, so the existing equation can still be used. |

**Discussion point 1.5: Should RRC processing delay defined in TS38.331 be changed for RedCap UE?** **Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)**

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | No | We do not see the clear motivation to make it different from non-RedCap UEs. |
| Qualcomm | Yes | We think relaxed RRC processing delay requirement is good to have  Justifications: RedCap use cases do not require stringent control-plane latency. Relaxed RRC processing time allows RedCap UEs to use a simpler processor and hence lowers their costs.  Values: introduce a scaling factor, which can take the values of 1.25x, 1.5x, 2.0x, for the RRC processing delay. |
| Huawei, HiSilicon | No | The current value is more than sufficient for RedCap UE.  This will also cause impact to the NW side. The relaxation of RRC processing delay will lead to longer RRC configuration fuzzy time, which is not beneficial for the resource scheduling efficiency of the network. |
| Futurewei | No | We share the concern on the potential impacts on the NW side. |
| Ericsson | No | This would have impact on the NW side and this cost reduction technique is not in the WI scope. |
| Samsung | No | Since it has been removed the WID, no need to consider it at least for Rel-17. |

**Discussion point 1.6: Should smaller scalingFactor be introduced for RedCap UE?** **Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)**

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | No | We do not see the clear motivation to make it different from non-RedCap UEs. In addition, it is unrelated to higher layer capability. |
| Qualcomm | - | Not sure which capability this scaling factor is for. |
| Spreadtrum | Yes | In Rel-15/16, *scalingFactor* is an UE capability reported to network, which is used to determine the max data rate. And the scaling factor is given by higher layer parameter *scalingFactor* and can take the values 1, 0.8, 0.75, and 0.4 in TS 38.306.  Based on the conclusion from RAN2#114 meeting, by default, all non-RedCap UE capabilities are applicable for RedCap UE.  However, as Rel-17 RedCap supports three use cases with quite different data rate requirements, e.g. less than 2 Mbps for industrial wireless sensor, and up to 150 Mbps for wearables, the current values of scaling factor non-RedCap UE for is not well matched the three use cases for RedCap, and the different scaling factor values for RedCap UE is necessary, e.g {1, 0.75, 0.4, 0.1}. In addition, we propose *scalingFactor* to be mandatory for RedCap UE. |
| Lenovo | Yes | Same view as Spreadtrum, a smaller scalingFactor could be introduced for RedCap UE. |
| Ericsson | No | As mentioned, smaller *scalingFactor* is already possible to use. Also in our understanding this has been discussed in RAN1 already and this discussion is not in RAN2 scope. |
| Samsung | No | The reason to introduce *scalingFactor* before was mainly due to the mismatch between RF and baseband capabilities, and the data rate ata rate would be bounded by the bandwidth anyway, so perhaps no need to update it for RedCap. |

**Discussion point 1.7: Should DRX defined for non-RedCap UE be changed for RedCap UE?** **Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)**

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | No | We do not see the clear motivation to make it different from non-RedCap UEs, especially considering eDRX will be introduced for RedCap UE. |
| Qualcomm | No |  |
| Lenovo | No |  |
| Huawei, HiSilicon | No |  |
| Futurewei | No |  |
| Ericsson | No | Not clear to us what is exactly being proposed and why. |
| Samsung | No | - |

1. Are there any other higher layer capabilities not applicable for RedCap UE? Please justify your response (please also indicate the details, e.g. not mandatory, changed value/value range, etc.)

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| --- | --- |
| **Company’s name** | **Companies’ views** |
| Huawei, HiSilicon | 1. Following proposals should also be agreed:    * Any capabilities related to MR-DC do not apply to RedCap UE.    * Any capabilities related to CA do not apply to RedCap UE. 2. In addition, we propose the ANR feature should be optional for RedCap UE (instead of mandatory as for non-RedCap UE). It is sufficient to rely on non-RedCap UEs to support the ANR from the NW perspective. No need to further mandatorily request RedCap UE to perform ANR, which cause a lot complexity. 3. We also want to clarify this email discussion does not touch the R16 feature yet. We may need to postpone the discussion on whether any R16 feature does not apply to RedCap UE. |
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# Phase 2- How to reflect the handling of RedCap specific capabilities

How to reflect the handling of RedCap specific capabilities (e.g. Maximum BW, Max Rx, MIMO-Layer, 256QAM, CA/DC, HD-FDD, etc.). Can take the principles in P3.x in R2-2106528 as an initial guideline.

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| **P3.x in R2-2106528**  Proposal 3.1. [To discuss] [15/25]  Revised Principle 1: For RedCap UE’s mandatory without signaling features:  which are optional or mandatory with capability signaling for non-RedCap UE, clarify in TS 38.306 in the definitions for existing parameters; Note “existing” is related to proposal1.  which are mandatory without capability signaling but with different value(s) for non-RedCap UE, clarify in TS 38.306 in the definition for new RedCap UE (FFS on new RedCap capability, type, etc); FFS on the need of new section  Proposal 3.2. [To discuss] [19/25] Principle 2.For RedCap UE’s optional features, which are mandatory without capability signaling for non-RedCap Ues (if any), or newly introduced in R17 for RedCap, add new UE capability signaling in TS 38.331 and capture the new definition in TS 38.306; FFS on the need of new section;  Proposal 3.3. [To discuss] [16/25] Revised Principle 3. For RedCap UE’s optional features, which are optional for non-RedCap UE but with different value (if any), extend the legacy capability signaling, and also capture the restriction in the definitions for existing parameters in TS 38.306; Note “existing” is related to proposal1.  Proposal 3.5. [To discuss] [16/25] Revised Principle 5. For the features not applicable to RedCap UE but mandatory without capability signaling supported by non-RedCap UE, clarify in TS 38.306 in the definition for new RedCap UE (FFS on new RedCap capability, type, etc). FFS on the need of new section; |

*<To be added by Rapporteur after completion of phase 1>;*

*Rapporteur will provide the example on how to capture Maximum BW, Max Rx, MIMO-Layer, 256QAM, CA/DC, HD-FDD and potential higher layer capabilities (based on outcome from phase 1)*

# Summary report and proposals

<Section to be updated by Rapporteur>

This report summarizes the views of xx companies ().

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.

1. **[To agree]** xxx
2. **[To discuss]** xxx
3. **[FFS]** xxx
4. xxxx.

# Conclusion

The observations captured are the following:

**Observation 1.** xxxx.

The proposals captured are the following:

**Proposal 1.** xxx

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

**Proposals for easy agreement**

xxx

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

xxx

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

xxx

# Annex: companies’ point of contact

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| --- | --- | --- |
| **Company** | **Point of contact** | **Email address** |
| Intel Corporation | Yi Guo | Yi.guo@intel.com |
| Lenovo | Jie Shi | Shijie4@lenovo.com |
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# Reference

1. R2-2106462 Summary 8.12.2.1 - Definition of RedCap UE and reduced capabilities (Intel)
2. R2-2106521 [offline 105] Definition of RedCap UE and reduced capabilities (Intel) Intel
3. R2-2106528 [offline 105] Definition of RedCap UE and reduced capabilities - second round Intel
4. TR 38.875
5. RP-210918, “Revised WID on support of reduced capability NR devices”
6. R2-2102017 Summary of offline 107 - [REDCAP] L2 capabilties and UE types Huawei