3GPP TSG-RAN WG1 Meeting #112 R1-23xxxxx

Athens, Greece, 27th February – 3rd March 2023

**Agenda Item: 8.6**

**Title: FL summary #1 on Rel-17 RedCap maintenance**

**Source: Moderator (Ericsson)**

**Document for: Discussion, Decision**

# Introduction

This feature lead (FL) summary (FLS) concerns the Rel-17 work item (WI) for support of reduced capability (RedCap) NR devices [[1](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_95e/Docs/RP-220966.zip), [2](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_96/Docs/RP-221163.zip)]. FLSs from the previous RAN1 meeting can be found in [[3](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_111/Docs/R1-2212530.zip), [4](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_111/Docs/R1-2212531.zip), [5](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_111/Docs/R1-2212532.zip), [6](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_111/Docs/R1-2212980.zip)], and a RAN1 agreement summary is available in [[7](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_111/Docs/R1-2212981.zip)].

This document summarizes contributions [8] – [25] submitted to agenda item 8.6 and the following email discussion:

|  |
| --- |
| [112-R17-RedCap] 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 – Johan (Ericsson) |

The issues in this document are tagged and color coded with High Priority or Medium Priority. The issues that are in the focus of this round of the email discussion are furthermore tagged FL1.

Follow the naming convention in this example:

* *RedCapFLS1-v000.docx*
* *RedCapFLS1-v001-CompanyA.docx*
* *RedCapFLS1-v002-CompanyA-CompanyB.docx*
* *RedCapFLS1-v003-CompanyB-CompanyC.docx*

If needed, you may “lock” a discussion document for 30 minutes by creating a checkout file, as in this example:

* Assume CompanyC wants to update *RedCapFLS1-v002-CompanyA-CompanyB.docx*.
* CompanyC uploads an empty file named *RedCapFLS1-v003-CompanyB-CompanyC.checkout*
* CompanyC checks that no one else has created a checkout file simultaneously, and if there is a collision, CompanyC tries to coordinate with the company who made the other checkout (see, e.g., contact list below).
* CompanyC then has 30 minutes to upload *RedCapFLS1-v003-CompanyB-CompanyC.docx*
* If no update is uploaded in 30 minutes, other companies can ignore the checkout file.
* Note that the file timestamps on the server are in UTC time.

In file names, please use the hyphen character (not the underline character) and include ‘v’ in front of the version number, as in the examples above and in line with the general recommendation (see slide 12 in [R1-2300003](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300003.zip)), otherwise the sorting of the files will be messed up (which can only be fixed by the RAN1 secretary).

To avoid excessive email load on the RAN1 email reflector, please note that there is NO need to send an info email to the reflector just to inform that you have uploaded a new version of this document. Companies are invited to enter the contact info in the table below.

**FL1 Question 0-1a: Please consider entering contact info below for the points of contact for this email discussion.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Point(s) of contact** | **Email address(es)** |
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| Qualcomm | Jing Lei | leijing@qti.qualcomm.com |
| Nokia, NSB | David Bhatoolaul | david.bhatoolaul@nokia.com |
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| LG Electronics | Jay KIM | Jaehyung.kim@lge.com |

# Issue #1: SDT operation

The previous RAN1 meeting made the following conclusions related to SDT operation for RedCap UEs [7]:

|  |
| --- |
| Conclusion:* No issue is identified for RedCap UEs supporting RA-SDT to support initial (non-subsequent) RA-SDT transmission in a RedCap-specific separate initial BWP without CD-SSB.

Conclusion:The following cases can be revisited in RAN1#112:* Subsequent RA-SDT transmission in a RedCap-specific separate initial BWP without CD-SSB
* CG-SDT in a RedCap-specific separate initial BWP without any SSB
* CG-SDT in a RedCap-specific separate initial BWP without CD-SSB but with NCD-SSB
 |

The previous RAN2 meeting agreed the following assumption [26]:

|  |
| --- |
| RAN2 Assumption:1. For CG-SDT purpose, RAN2 has basic assumption that SSB will be configured in initial BWP with CG-SDT. For RedCap FFS if SSB refers to CD-SSB or any SSB
 |

Some related earlier RAN1 agreements [27, 28]:

|  |
| --- |
| Conclusion:RA-SDT and CG-SDT can be supported for RedCap UEs without considering specific optimization for RedCap, at least when RedCap UE share both the initial DL BWP and initial UL BWP with non-RedCap UEs.Agreement:RAN1 confirms that the separate BWP in case of RedCap may still be considered as the initial BWP and SDT resources (both CG-SDT and RA-SDT) can hence be configured on this BWP for RedCap UEs.* Note: details can be further studied to ensure proper functionality of RedCap UE performing SDT.

Agreement:The validation rule defined for CG-SDT in FD-FDD mode can be reused for RedCap UE performing CG-SDT in HD-FDD mode. |

Some related earlier RAN2 agreements [29]:

|  |
| --- |
| Agreements:1. During the SDT procedure (i.e., while SDT timer is running), UE monitors SI change indication in any paging occasion at least once per modification period (i.e., same as legacy RRC\_CONNECTED).
2. During the SDT procedure (i.e., while SDT timer is running), ETWS or CMAS capable UEs monitors PWS notification in any paging occasion at least once every *defaultPagingCycle* (i.e., same as legacy RRC\_CONNECTED).
 |

Now, the following contributions have been submitted to this RAN1 meeting about SDT operation for RedCap UEs:

|  |  |  |  |
| --- | --- | --- | --- |
| [8] | [R1-2300367](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300367.zip)(Section 2.1) | Discussion on RedCap remaining issues | ZTE, Sanechips |
| [10] | [R1-2300418](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300418.zip) | Remaining issues on SDT support for Rel-17 RedCap UE | Vivo |
| [11] | [R1-2300499](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300499.zip) | Support for SDT in a RedCap-specific initial DL BWP without SSB | Ericsson |
| [12] | [R1-2300542](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300542.zip) | Discussion on remaining details of RedCap SDT operation | Xiaomi |
| [13] | [R1-2300648](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300648.zip) | Discussion on SDT in separate initial BWP without CD-SSB | CATT |
| [15] | [R1-2300854](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300854.zip) | Remaining issue of Rel-17 RedCap UE | NEC |
| [16] | [R1-2300977](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300977.zip) | Discussion on SDT procedure related RedCap remaining issues | CMCC |
| [17] | [R1-2301148](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301148.zip) | RedCap support of SDT | Nokia, Nokia Shanghai Bell |
| [18] | [R1-2301328](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301328.zip) | On Small Data Transmission for Redcap UEs | Apple |
| [19] | [R1-2301387](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301387.zip)(Section 4) | Remaining Issues on UE Complexity Reduction | Qualcomm Incorporated |
| [21] | [R1-2301471](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301471.zip)(Section 2.2) | Discussion on corrections and SDT operations for RedCap UE | NTT DOCOMO, INC. |
| [23] | [R1-2301723](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301723.zip) | Remaining issues during SDT procedure for RedCap UEs | Huawei, HiSilicon |
| [24] | [R1-2301781](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301781.zip)(Section 2) | On RedCap remaining issues (revision of [R1-2301606](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301606.zip)) | MediaTek Inc. |

Many contributions express views on the following three cases which were identified in the previous RAN1 meeting:

* **Case A: Subsequent RA-SDT transmission in a RedCap-specific separate initial BWP without CD-SSB**
	+ Several contributions [8, 11, 13, 16, 17, 21] express that this case may be supported at least for RedCap UEs that support an optional capability (e.g., FG 28-1a).
	+ Several contributions [8, 13, 17, 19, 24] express that this case should not be supported at all or at least not by RedCap UEs that do not support an optional capability (e.g., FG 28-1a).
* **Case B: CG-SDT in a RedCap-specific separate initial BWP without any SSB**
	+ Several contributions [8, 11, 13, 15, 16, 17, 18, 21] express that this case may be supported at least for RedCap UEs that support an optional capability (e.g., FG 28-1a).
	+ Several contributions [8, 13, 15, 18, 19, 24] express that this case should not be supported at all or at least not by RedCap UEs that do not support an optional capability (e.g., FG 28-1a).
* **Case C: CG-SDT in a RedCap-specific separate initial BWP without CD-SSB but with NCD-SSB**
	+ Several contributions [8, 10, 11, 18, 19, 24] express that this case may be supported.
	+ Several contributions [13, 15, 16, 17, 21] express that this case should not be supported.
	+ One contribution [23] expresses that it should be left up to RAN2/RAN4 whether to support this case.

For RA-SDT-related Case A, the following subcases (analogous to CG-SDT-related Cases B and C) can be considered:

* **Case A1: Subsequent RA-SDT transmission in a RedCap-specific separate initial BWP without any SSB**
* **Case A2: Subsequent RA-SDT transmission in a RedCap-specific separate initial BWP without CD-SSB but with NCD-SSB**

Several contributions discuss how to handle, e.g., monitoring of paging and SI update notifications during SDT procedure in the above cases. Some contributions suggest that it may be left up to the NW and/or UE implementation. It can be expected that RAN2 will also discuss some of these aspects for these cases during this meeting. Nevertheless, it may be relevant to collect views on support of these cases from RAN1 perspective. Below, there is one question for each case.

**FL1 Question 1-1a: Should Case A1 (subsequent RA-SDT transmission in a RedCap-specific separate initial BWP without any SSB) be supported? Please elaborate on the motivation and potential conditions in the comment field.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | N | Firstly, given RAN2 already agreed that “RAN2 has basic assumption that SSB will be configured in initial BWP with CG-SDT” we think it is better for RAN1 to have aligned views with RAN2’s assumption to avoid the risk that RAN1 and RAN2 support different cases and developed different options. Although RAN2’s agreement is for CG-SDT, we think it should be applied to RA-SDT with subsequent transmission as well. Secondly, supporting SDT in a initial BWP without SSB is very difficult for RedCap UE to maintain the sync, meet UL transmission timing accuracy. RedCap UE needs to switch back and forth between the legacy initial BWP for CD-SSB measurement and separate initial BWP for SDT transmission. It increase RedCap UE power consumption, SDT transmission delay, defeating the SDT benefits.  |
| Qualcomm |  | It would be challenging or impossible for a RedCap UE to support Case A1, if the RedCap UE does not support FG 28-1a. |
|  Nokia, NSB | Y with FG28.1a | During this maintenance phase, we would like to see SDT supported but with minimal impacts to both the specifications and/or the network and UE. For us, a good compromise, is to restrict the support of this case to UEs that support FG28.1a, provided it can be agreed that support of FG28.1a, means that for this scenario, that neither the network or UE, have to make special adjustments/assumptions (eg measurement gaps, different UE retuning times) for SDT scheduling. |
| CATT | N at least for non-FG 28-1a UE | 1) For RedCap UE not capable with FG 28-1a, this case is not supported by nature.2) For RedCap UE supporting FG 28-1a , we think this can be supported. But due to RAN2’s basic assumption on CG-SDT (seems no inner difference with RA-SDT on use of SSB), we are also OK to conclude that this case is not support. |
| Spreadtrum | Slightly prefer N | In general view, the separate initial DL BWP does not contain CD-SSB. It was agreed there could be no any SSB for RACH and initial transmission of RA-SDT. This implies that RedCap UE without FG 28-1a may process RACH and initial transmission of RA-SDT without processing any SSB. It is feasible, since the duration is short. However, for the subsequent RA-SDT, it may not be feasible. From UE vendor perspective, it is better NW can provide NCD-SSB for this case. Otherwise, the share initial DL BWP is expected for RA-SDT. |
| ZTE, Sanechips | N if Case A2 is supported | Actually the option that no SSB is configured for CG-SDT is also on the table of RAN2 discussion, they will further discuss 3 options in this meeting. From our understanding, we should firstly discuss Case A2, if NCD-SSB can be used for SDT, then there is no need to discuss the Case A1. |
| Nordic  | Y | We do not see this option being different to regular R17 RACH procedure on the separate initial BWP without SSB. UE may send small data in MSG3. Or is there some difference? |
| Intel | Y | Same view as Nordic – we do not see a difference compared to regular RA procedure or “initial RA-SDT”.  |
| NEC |  | N for a RedCap UE without FG28-1a assuming during RA-SDT procedure a RedCap UE needs to stay on a separate initial DL BWP without SSB.On the other hand, it would be feasible a RedCap UE with FG28-1a supports Case A1 because subsequent RA-SDT transmission on a separate initial BWP without SSB is similar to operation on an active BWP without SSB in RRC\_CONNECTED. RAN1 may discuss its feasibility.On RAN2 agreement of presence of SSB, a case without SSB is still on the table for CG-SSB in RAN2. So RAN1 should not conclude this due to RAN2 agreements. |
| DOCOMO | Y | This case can be supported without any RAN1 impact and can be handled by gNB implementation. |
| MediaTek | N | The time span of SDT (SDT timer T319a <= 4000ms) could be much larger than a RACH procedure (~<=100ms). How can one expect an Inactive-mode UE to be synchronized for 4000ms in a BWP w/o SSB? Unlike connected mode, there is no CSI-RS or TRS to be measured by UE for synchronization. SSB is what UE in Inactive mode can rely on for DL synchronization and UL timing adjustment. If UE has to continue switching back and forth between RedCap-specific initial BWP (containing no SSB) and legacy (i.e. non-Redcap) initial BWP during SDT, we wonder whether the shorter latency and less UE power consumption benefits claimed by SDT still hold. Our proposal is that for Rel-17, SDT should be only supported in an initial BWP with SSB. FFS: SSB only includes CD-SSB or both CD-SSB and NCD-SSB. |
| LGE | N | Share the view with vivo. No at least if FG 28-1a is not supported. |

**FL1 Question 1-2a: Should Case A2 (subsequent RA-SDT transmission in a RedCap-specific separate initial BWP without CD-SSB but with NCD-SSB) be supported? Please elaborate on the motivation and potential conditions in the comment field.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | Y | Separate initial BWP without CD-SSB is one typical use case for RedCap UEs. If SDT is supported for RedCap, it is necessary and more worthwhile to support Case A2. As long as network configures the separate initial BWP without CD-SSB, it is expected that there will be at least one connected RedCap UEs supporting basic functionality i.e., FG28-1 and NCD-SSB. NW overhead will not be increased and RedCap UE complexity can be reduced.  |
| Qualcomm | Y | * If NCD-SSB is configured in the RedCap-specific initial DL BWP on unpaired spectrum, NCD-SSB should only fall in DL/flexible symbols of a TDD slot.
* Similar to CD-SSB, a RedCap UE does not expect symbols of NCD-SSB to overlap with UL symbols of a TDD slot.
* To validate ROs used for RA-SDT, RedCap UE needs to consider both CD-SSB and NCD-SSB. Therefore, it is desirable for NW to configure *ssb-TimeOffset-r17* to be zero in a RedCap-specific initial DL BWP with NCD-SSB.
 |
| Nokia, NSB | Y with FG28.1a | Our initial answer, “Y with FG28.1a”, effectively ignores whether NCD-SSB is there or not, i.e. provided FG28.1a is supported, this case of SDT can be supported with or without NCD-SSB. Our current understanding is that NCD-SSB is only supported for connected mode UEs. If this is correct, then we ask supporters of this proposal, to clarify:(1) Is the assumption that NCD-SSB is always present if configured for connected mode UEs?(2) Is a new way to specify NCD-SSB for idle-inactive UEs required? If a new way is specified, do we need to ensure that 2x NCD-SSB aren’t created in the same BWP?  |
| CATT | N | We think this will lead to some RRC modification (e.g. adding NCD-SSB configuration IE in SIB). In this phase, we’d better avoid this kind of change. |
| Spreadtrum | Slightly prefer Y | Like **FL1 Question 1-1a** |
| ZTE, Sanechips | Y | Motivation: In separate initial BWP without CD-SSB, if NCD-SSB is not supported for SDT, UE has to switch to initial BWP to maintain the sync and timing, which increases the UE complexity.Spec impact: NCD-SSB configuration can be added in RRC release message dedicated for SDT operation, no other spec change is needed. If spec change is the main concern, we can send an LS to RAN2 for them to decide based on the required spec change.NW overhead: If separate initial BWP without CD-SSB is configured, it implies that there exists at least one connected UE is configured with NCD-SSB, then the same NCD-SSB can be configured for SDT UE in inactive state, NW overhead is not increased. |
| Nordic  | Y | This would work for sure. |
| Intel | Y (conditional) | This is assuming that NCD-SSB configuration is still limited to dedicated RRC signalling and does not imply any impact to SIB signalling. |
| NEC | N | NCD-SSB is not available in RRC\_INACTIVE and difficult to conclude whether case A2 is supported from RAN1 point of view at this late stage. On the other hand, case A2 is also on the table in RAN2. If RAN2 agrees to introduce NCD-SSB in RRC\_INACTIVE, support of case A2 would be feasible for a RedCap UE with FG28-1a, but not feasible for a RedCap UE without FG28-1a due to the same reason as question 1-1a. |
| DOCOMO | N | It was agreed at the previous RAN1 meeting that NCD-SSB is supported for a UE in RRC connected state and not for RRC idle/inactive state. This principle should not be revised. |
| MediaTek | Y | From UE implementation perspective, SDT should be only supported in an initial BWP that contains SSB. We think CD-SSB is sufficient but for progress we can also support NCD-SSB. However, to fully ease UE implementation, the following companion proposals to support NCD-SSB should be also considered. **Proposal:** UE is not required to monitor SI change indication and PWS notification during a SDT procedure in a RedCap-specific initial BWP that does not contain full CD-SSB and CORESET#0. Send LS to RAN2.  |
| LGE | Y (conditional) | Case A2 can be supported if the related signaling is supported in RAN2. |

**FL1 Question 1-3a: Should Case B (CG-SDT in a RedCap-specific separate initial BWP without any SSB) be supported? Please elaborate on the motivation and potential conditions in the comment field.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | N | Same comments as for Question1-1a for CaseA1. In addition, for CG resource validation, SSB measurement is also required. The periodicity of CG resource can be small, it increases more frequent switching to the legacy initial BWP for CD-SSB measurement. Such interruption is not desirable from NW perspective and the increased RedCap UE power consumption, SDT transmission delay also defeat the SDT benefits..  |
| Qualcomm |  | It would be challenging or impossible for a RedCap UE to support CG-SDT in a separate initial DL BWP without SSB, if the RedCap UE does not support FG 28-1a. |
| Nokia, NSB | Y with FG28.1a | See our question 1-1a response, plus a desire for simple consistency across the various cases. |
| CATT | N at least for non-FG 28-1a UE | Same comment as that of Case A1. |
| Spreadtrum | Slightly prefer N | RACH and initial transmission of RA-SDT is short in duration in general view. That is why we have agreed without any SSB in the previous meetings. However, it may not be true for CG-SDT, as mentioned by vivo CG-SDT is too dense and there is no gap for retuning RF to process SSB outside the separate initial DL BWP. |
| ZTE, Sanechips | N if Case C is supported | From our understanding, we should firstly discuss Case C, if NCD-SSB can be used for SDT, then there is no need to discuss the Case B. |
| Nordic  | N |  |
| Intel | N | Considering shorter periodicity values of CG-SDT resources, it may be challenging for a UE if SSB measurement is needed in between. |
| NEC |  | Same comment as Case A1. |
| DOCOMO | Y | Similar to case A1, this case can be supported without any RAN1 impact. |
| MediaTek | N | Similar view as our response to Question 1-1a. SDT should be only supported in an initial BWP with SSB. Otherwise, we are not sure the merits claimed by SDT such as lower latency and less UE power consumption remain.  |
| LGE | N | We also think supporting Case B is challenging for RedCap UE. |

**FL1 Question 1-4a: Should Case C (CG-SDT in a RedCap-specific separate initial BWP without CD-SSB but with NCD-SSB) be supported? Please elaborate on the motivation and potential conditions in the comment field.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | Y | Same comments as for Question 1-2a for Case A2. |
| Qualcomm | Y | * If NCD-SSB is configured in the RedCap-specific initial DL BWP on unpaired spectrum, NCD-SSB should only fall in DL/flexible symbols of a TDD slot.
* Similar to CD-SSB, a RedCap UE does not expect symbols of NCD-SSB to overlap with UL symbols of a TDD slot.
* To validate CG-PUSCH occasions used for CG-SDT (and ROs of RA procedure, if UE fall backs to 4-step or 2-step RA), RedCap UE needs to consider both CD-SSB and NCD-SSB. Therefore, it is desirable for NW to configure *ssb-TimeOffset-r17* to be zero in a RedCap-specific initial DL BWP with NCD-SSB.
 |
| Nokia, NSB | Y with FG28.1a | See our question 1-2a response. |
| CATT | N | We think this will lead to some RRC modification (e.g. adding NCD-SSB configuration IE in RRC release information). In this phase, we’d better avoid this kind of change. |
| Spreadtrum | Slightly prefer Y | Like **FL1 Question 1-3a** |
| ZTE, Sanechips | Y | Motivation: In separate initial BWP without CD-SSB, if NCD-SSB is not supported for SDT, UE has to switch to initial BWP to maintain the sync and timing, as well as SSB measurement for SSB to CG PUSCH mapping, which increases the UE complexity.Spec impact: NCD-SSB configuration can be added in RRC release message dedicated for SDT operation, no other spec change is needed. If spec change is the main concern, we can send an LS to RAN2 for them to decide based on the required spec change.NW overhead: If separate initial BWP without CD-SSB is configured, it implies that there exists at least one connected UE is configured with NCD-SSB, then the same NCD-SSB can be configured for SDT UE in inactive state, NW overhead is not increased. |
| Nordic  | Y |  |
| Intel | Y (conditional) | This is assuming that NCD-SSB configuration is still limited to dedicated RRC signalling and does not imply any impact to SIB signalling. |
| NEC |  | Same comment as Case A2. |
| DOCOMO | N | Similar to case A2, NCD-SSB cannot be transmitted for RRC inactive state, thus it should not be supported. |
| MediaTek | Y | Same comments as for Question 1-2a for Case A2. |
| LGE | Y (conditional) | Case C can be supported if the related signaling is supported in RAN2. |

# Issue #2: HD-FDD operation

The following contributions concern HD-FDD operation for RedCap UEs:

|  |  |  |  |
| --- | --- | --- | --- |
| [14] | [R1-2300649](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300649.zip)(38.213 CR) | Correction on impact of HD-FDD operation in Rel-17 | CATT |
| [20] | [R1-2301470](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301470.zip)(38.213 CR) | Correction on reference clauses for PDCCH repetition, UCI multiplexing/prioritization, and PUCCH transmission for HD-FDD operation | NTT DOCOMO, INC. |
| [21] | [R1-2301471](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301471.zip)(Section 2.1) | Discussion on corrections and SDT operations for RedCap UE | NTT DOCOMO, INC. |

The draft CRs add references to clause 17.2 (which concerns HD-FDD procedures) in several clauses in 38.213.

**FL1 Question 2-1a: Companies are invited to provide comments and suggested priority (Low/Medium/High).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Priority** | **Comments** |
| vivo | H | We are OK to discuss it. |
| Nokia, NSB | M |  |
| CATT | H | We should add these references to complete the feature. |
| Spreadtrum | H |  |
| ZTE, Sanechips | M or L | I guess it also works if no correction. |
| Nordic | H | OK to discuss, but ZTE has point |
| Intel | M or L | Same view as ZTE and Nordic; may not be essential, but ok to discuss. |
| DOCOMO | H |  |
| LGE | M | Okay to discuss. |

# Issue #3: Initial DL BWP configuration

The following contribution concerns initial DL BWP configuration for RedCap UEs:

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| [19] | [R1-2301387](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301387.zip)(Section 2) | Remaining Issues on UE Complexity Reduction | Qualcomm Incorporated |

The contribution proposes to revisit a RAN2 agreement which may conflict with RAN1 agreement and specification.

**FL1 Question 3-1a: Companies are invited to provide comments and suggested priority (Low/Medium/High).**

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| **Company** | **Priority** | **Comments** |
| Vivo | M or L | We have a different understanding for following RAN1 specification. “For an initial DL BWP provided by initialDownlinkBWP-RedCap in DownlinkConfigCommonSIB, if a UE in RRC\_IDLE state or in RRC\_INACTIVE state monitors PDCCH according to Type1-PDCCH CSS set and does not monitor PDCCH according to Type2-PDCCH CSS set, the UE does not expect the initial DL BWP to include SS/PBCH blocks and the CORESET with index 0.”Above specification just specifies that when RedCap UE does not monitor Type2-PDCCH CSS set, the UE does not expect the initial DL BWP to include SS/PBCH blocks + CORESET with index 0. But it cannot be interpreted that when RedCap UE monitors Type2-PDCCH CSS set, the the initial DL BWP shall include SS/PBCH blocks + CORESET with index 0. From our undersatnding, when RedCap monitors Type2-PDCCH CSS set, the initial DL BWP shall include SS/PBCH blocks, not necessrily include CORESET#0. For leagcy UE, the Type 2 PDCCH CSS set does not need to always associated with CORESET#0, SIB1 can configure another common CORESET for Type 2 PDCCH CSS set.  |
| Qualcomm | H | According to RAN1 agreements and R17 specifications (TS 38.213 and TS 38.331), a RedCap UE is not expected to be configured with a paging and OSI CSS when the RedCap-specific initial DL BWP does not include the entire CORESET#0. However, the following RAN2 agreement allows NW to configure separate CSS sets for paging/OSI, which contradicts with RAN1’s agreements and current specifications: * *“If paging and OSI search space are configured in the RedCap-specific initial DL BWP which contains CD-SSB, it is up to NW configuration whether the associated physical time/frequency domain resources can be the same as or different from the ones in the legacy initial DL BWP (FFS whether we need to update the field description).”*

Therefore, we propose to **send an LS to RAN2, and ask RAN2 to revisit the agreement inconsistent with TS 38.213 and TS 38.331**. We don’t think RAN1 needs to spend much time on discussing how to revise the agreement of RAN2. |
| Nokia, NSB | M |  |
| CATT | M or L |  |
| Spreadtrum | H (potential duplication and/or conflicting for RAN1/RAN2 spec) | As we mentioned in our previous contributions, we thought there were many RAN1 agreement tried to address CORESET#0, but we discussed it for SSB issues, so in our view CORESET#0 issues can be left to RAN2. Maybe we need to revisit the agreements mentioning both SSB and CORESET#0, and if necessary, we can remove some descriptions on CORESET#0 from RAN1 spec. In our memory, there are some texts on CORESET#0 have been captured in 38.331 for paging/SIB1/OSI/RACH search space configurations. |
| ZTE, Sanechips |  | No spec conflict is observed, even when separate paging CSS is configured, since NW will guarantee that it is configured in the BWP with CD-SSB and CORESET#0.If the motivation for sending the LS is clear, we would be open to discuss. Hope more necessity is presented. |
| Nordic | L | separate BWP not containing CORESET#0 should not contain paging SS, based on previous RAN1 agreements.for separate BWP containing CORESET#0, gNB could configure separate RedCap specific CommonCORESET, but gNB should make sure UE is not required to monitor more than 2 CORESETs In other words, 2CORESET restriction should solve the issue here. |
| Intel | L | We share the interpretation from vivo and do not see a contradiction between RAN1 specs and RAN2 decision. |
| DOCOMO | L | TS38.213 and 331 has been already addressed. Thus, we don’t see the strong need to clarify that RAN2 agreement intends that Type 2 CSS can be configured to be monitored when RedCap specific separate initial BWP contains CD-SSB and **entire CORESET#0**. |
| LGE | L | We share the view vivo and Intel. We also don’t see a direct contradiction b/w RAN1 and RAN2 agreements. |

# Issue #4: Separate CSS configuration

The following contribution concerns separate CSS configuration for RedCap UEs:

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| [19] | [R1-2301387](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301387.zip)(Section 3) | Remaining Issues on UE Complexity Reduction | Qualcomm Incorporated |

The contribution proposes to specify rules to ensure consistent CSS configuration for RedCap and non-RedCap UEs.

**FL1 Question 4-1a: Companies are invited to provide comments and suggested priority (Low/Medium/High).**

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| **Company** | **Priority** | **Comments** |
| Vivo |  | It would be good to have consistent CSS configuration that can be achieved by NW implementation. So, we are not sure whether it is essential or necessary.  |
| Qualcomm | H | We think consistent/shared CSS configurations are essential to avoid ambiguity of NW configuration and UE implementation due to the following reasons:* using the same time/frequency resources saves the system overhead of NW
* monitoring the same CSS sets associated with a common CORESET (e.g., CORESET#0, or the additional CORESET shared by the initial DL BWPs of RedCap and non-RedCap UEs) reduces the implementation complexity for all UEs
* shared CSS configurations comply with existing agreements and specifications for RedCap/non-RedCap UEs
* avoiding extra discussions and specification efforts on avoiding or handling the duplicates/collisions of broadcast information on different time/frequency resources
 |
| Nokia, NSB | M | We are OK to discuss. We have marked as M, as with initially see this more as an optimization/restriction. |
| CATT |  | We think current spec supports what the contribution is proposing, and probably a natural choice from NW’s view. Additional restriction seems unnecessary.  |
| Spreadtrum | Y (Combined to Issue #3) | We think RAN2 spec is more complete and RAN2 had more plenty of discussion for CORESET#0 related issues. Some corner cases had been excluded in RAN2 spec in our understanding. As for Issue #3, we think the texts for CORESET#0 in RedCap Section of 38.213 can be removed, and RAN2 spec is clear, e.g. 38.331. |
| ZTE, Sanechips | L | For the UE, separate configuration or shard configuration shows no difference. For the gNB, separate CSS, e.g., for paging, also has some benefits of offloading in some cases. We don’t see the necessity to revert RAN2’s conclusion. |
| Nordic | L | CSS can be either in RedCapCommonCORESET or in CORESET#0, it cannot be in nonRedCapCommonCORESET, because it would break the 2CORESET capability rule. We do not think there is an issue.   |
| Intel | L | Same view as Nordic. |
| DOCOMO | L | In our understanding, it can be achieved by NW configuration with current specification, and hence the motivation is unclear for us. |
| LGE | L | Share the view with Nordic and Intel. |

# Issue #5: PRACH/PUSCH occasion validation

The following contributions concern PRACH/PUSCH occasion validation for RedCap UEs:

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| [24] | [R1-2301781](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301781.zip)(Section 3) | On RedCap remaining issues (revision of [R1-2301606](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301606.zip)) | MediaTek Inc. |
| [25] | [R1-2301782](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301782.zip)(38.213 CR) | Draft CR on validation of PRACH and PUSCH occasions with NCD-SSB (revision of [R1-2301607](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301607.zip)) | MediaTek Inc. |

PRACH/PUSCH occasion validation was also discussed in the previous RAN1 meeting, see Issue #4 in the FLS in [3].

**FL1 Question 5-1a: Companies are invited to provide comments and suggested priority (Low/Medium/High).**

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| **Company** | **Priority** | **Comments** |
| Vivo | L or M | The correction may not be needed since current Clause 8.1 and 8.1A defines the valid PRACH/PUSCH is determined based on the SSB provided by *ssb-PositionsInBurst* in SIB1 or in *ServingCellConfigCommon*   |
| Qualcomm |  | * If NCD-SSB is configured in the initial/non-initial DL BWP of RedCap UE on unpaired spectrum, NCD-SSB should only fall in DL/flexible symbols. and do not fall in UL symbols of a TDD slot, which is similar to CD-SSB.
* Based on current spec (Clause 17.1 of TS 38.213), a RedCap UE should use both CD-SSB and NCD-SSB for RO validation on unpaired spectrum.
 |
| Nokia, NSB | Low | Similar view as Vivo.  |
| CATT | L | Similar view as vivo. |
| Spreadtrum | L | Pending after SDT issues are solved. |
| ZTE, Sanechips | M | We are OK to discuss this issue. If no correction is needed, we can have a conclusion. |
| Nordic | H | We think it should be fine to validate based on CD-SSB only, in RRC connected, UE may measure NCD-SSB before intended PRACH or PDCCH order. But lets discuss.  |
| Intel | L | Same view as vivo. |
| DOCOMO | L | Similar view as vivo. |
| MediaTek | H | About vivo’s comment, strictly speaking, Clause 8.1 and 8.1A mainly clarify that “the SSB candidate index” is from “the SSB index” indicated in ssbPositionInBurst in SIB1 or ServingCellConfigCommon. This clarifies about SSB candidate indices and SSB indices (Note: These two may be different in unlicensed operation). But this does not say the SSBs are CD-SSBs in our opinion. NCD-SSBs shares the exact same SSB indices with their corresponding CD-SSBs. With the TP in 17.1 on top of 8.1, some companies think UE configured with NCD-SSB should apply NCD-SSB instead From our offline discussion with companies, different companies have different understanding about which SSBs (CD-SSB, NCD-SSB, both, or none) should be applied for the new cases introduced by RedCap: BWP containing no SSB, and BWP containing NCD-SSB but not CD-SSB. * For example, with the TP in 17.1 on top of 8.1, some companies think UE configured with NCD-SSB should apply NCD-SSB instead CD-SSB, some companies think both NCD-SSB and CD-SSB should be applied, while others think only CD-SSB is applied. We have got three different answers for this case already! 😊

We really think RAN1 should spend some time to align companies understanding on this issue. **Proposal 1:** For TDD, RAN1 clarifies **which SSBs** should be applied by UE for PRACH occasion validation per 8.1 and 17.1 in the following cases* Case 1-1: UE performing RACH in initial access in RedCap-specific initial BWP w/o any SSB
* Case 1-2: A connected RedCap UE configured with NCD-SSB in the RedCap-specific initial BWP w/o CD-SSB
* Case 2: A RedCap UE supporting both FG28-1 and 28-1a not configured with any SSB for all RRC states in the RedCap-sp

**Proposal 2:** For TDD, if it is agreed that a UE may apply different SSBs and hence may result in different *valid* RO-SSB association patterns for different RRC states, RAN1 further clarifies ***when exactly*** UE should apply which SSB-RO association pattern. |
| LGE | L | Share the view with vivo. |

# Issue #6: PUSCH TDRA misalignment

The following contributions concern PUSCH TDRA misalignment for RedCap UEs:

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| [8] | [R1-2300367](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300367.zip)(Section 2.2) | Discussion on RedCap remaining issues | ZTE, Sanechips |
| [9] | [R1-2300368](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300368.zip)(38.214 CR) | Correction on TDRA misalignment of PUSCH for RedCap | ZTE, Sanechips |

PUSCH TDRA misalignment was also discussed in the previous RAN1 meeting, see Issue #3 in the FLS in [3].

**FL1 Question 6-1a: Companies are invited to provide comments and suggested priority (Low/Medium/High).**

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| **Company** | **Priority** | **Comments** |
| Vivo | L | Not needed. It can be handled by gNB implementation/proper configuration |
| Qualcomm | M | OK to discuss if time allows. |
| Nokia, NSB | L |  |
| CATT | L | This issue may be valid, but we are not sure it is essential since many gNB implementation methods can address it.  |
| Spreadtrum | M | CORESET#0 may be updated in 38.214 to “initial DL BWP”? We think CORESET#0 in the TDRA table means initial DL BWP. It is OK for legacy, but is not so correct for RedCap. |
| ZTE, Sanechips | H | This issue is better to be addressed before widely deployed, since it would limit the gNB configuration for PUSCH if it is left to gNB implementation and finally cause the lower system efficiency. |
| Nordic | L |  |
| Intel | L |  |
| DOCOMO | L | NW can avoid the misalignment issue. Thus we don’t see the need to discuss it in this meeting. |
| LGE | L | Okay to discuss if time allows, but don’t see an urgency on this issue. |

# Issue #7: PUSCH repetition type B

The following contribution concern PUSCH repetition type B for RedCap UEs:

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| [22] | [R1-2301542](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301542.zip)(38.214 CR) | Corrections on invalid symbol determination for PUSCH repetition Type B transmission for RedCap UE | Sharp, Vivo |

PUSCH repetition type B for HD-FDD was addressed by the agreed CR in [30], and now this draft CR addresses TDD.

**FL1 Question 7-1a: Companies are invited to provide comments and suggested priority (Low/Medium/High).**

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| **Company** | **Priority** | **Comments** |
| Vivo | H | As FL mentioned, PUSCH repetition type B for HD-FDD was addressed by the agreed CR in [30], and now this draft CR is to addresses for TDD case. |
| Qualcomm | M | OK to discuss if time allows. |
| Nokia, NSB | M |  |
| CATT | M | OK. |
| Spreadtrum | M |  |
| ZTE, Sanechips | L | It seems to be covered by the following:For a RedCap UE indicated presence of SS/PBCH blocks within an active DL BWP by *NonCellDefiningSSB* in unpaired spectrum, collision handling between uplink transmissions and the SS/PBCH blocks are same as described for a UE indicated presence of SS/PBCH blocks by *ssb-PositionsInBurst* in *SIB1* or in *ServingCellConfigCommon* described in all other clauses, unless otherwise stated. |
| Nordic  | M |  |
| Intel | M/H | OK to discuss. |
| DOCOMO | H | This CR should be applied same as PUSCH repetition type B for HD-FDD. Thus, we are fine to discuss it in this meeting. |
| Sharp | H | The description quoted by ZTE is from TS38.213. We cannot interpret that the description in TS 38.213 can also cover TS38.214 without a specific reference to TS38.214. In our view, without adding a spec reference, “all other clauses” refers to the document TS38.213 itself and cannot extent to other documents. Therefore, comparing to adding references, for example, “in all other clauses of the document and [6, TS 38.214]”, correction in the draft CR is a simple way to address for TDD case. |
| LGE | M | Okay to discuss. |

# References

|  |  |  |  |
| --- | --- | --- | --- |
| [1] | [RP-220966](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_95e/Docs/RP-220966.zip) | Revised WID on support of reduced capability NR devices | Ericsson |
| [2] | [R1-221163](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_96/Docs/RP-221163.zip) | Summary of WI on support of reduced capability (RedCap) NR devices | Ericsson |
| [3] | [R1-2212530](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_111/Docs/R1-2212530.zip) | FL summary #1 on Rel-17 RedCap maintenance | Moderator (Ericsson) |
| [4] | [R1-2212531](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_111/Docs/R1-2212531.zip) | FL summary #2 on Rel-17 RedCap maintenance | Moderator (Ericsson) |
| [5] | [R1-2212532](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_111/Docs/R1-2212532.zip) | FL summary #3 for Rel-17 RedCap maintenance | Moderator (Ericsson) |
| [6] | [R1-2212980](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_111/Docs/R1-2212980.zip) | FL summary #4 for Rel-17 RedCap maintenance | Moderator (Ericsson) |
| [7] | [R1-2212981](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_111/Docs/R1-2212981.zip) | RAN1 agreements for Rel-17 NR RedCap | Rapporteur (Ericsson) |
| [8] | [R1-2300367](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300367.zip) | Discussion on RedCap remaining issues | ZTE, Sanechips |
| [9] | [R1-2300368](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300368.zip) | Correction on TDRA misalignment of PUSCH for RedCap | ZTE, Sanechips |
| [10] | [R1-2300418](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300418.zip) | Remaining issues on SDT support for Rel-17 RedCap UE | Vivo |
| [11] | [R1-2300499](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300499.zip) | Support for SDT in a RedCap-specific initial DL BWP without SSB | Ericsson |
| [12] | [R1-2300542](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300542.zip) | Discussion on remaining details of RedCap SDT operation | Xiaomi |
| [13] | [R1-2300648](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300648.zip) | Discussion on SDT in separate initial BWP without CD-SSB | CATT |
| [14] | [R1-2300649](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300649.zip) | Correction on impact of HD-FDD operation in Rel-17 | CATT |
| [15] | [R1-2300854](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300854.zip) | Remaining issue of Rel-17 RedCap UE | NEC |
| [16] | [R1-2300977](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2300977.zip) | Discussion on SDT procedure related RedCap remaining issues | CMCC |
| [17] | [R1-2301148](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301148.zip) | RedCap support of SDT | Nokia, Nokia Shanghai Bell |
| [18] | [R1-2301328](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301328.zip) | On Small Data Transmission for Redcap UEs | Apple |
| [19] | [R1-2301387](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301387.zip) | Remaining Issues on UE Complexity Reduction | Qualcomm Incorporated |
| [20] | [R1-2301470](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301470.zip) | Correction on reference clauses for PDCCH repetition, UCI multiplexing/prioritization, and PUCCH transmission for HD-FDD operation | NTT DOCOMO, INC. |
| [21] | [R1-2301471](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301471.zip) | Discussion on corrections and SDT operations for RedCap UE | NTT DOCOMO, INC. |
| [22] | [R1-2301542](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301542.zip) | Corrections on invalid symbol determination for PUSCH repetition Type B transmission for RedCap UE | Sharp, Vivo |
| [23] | [R1-2301723](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301723.zip) | Remaining issues during SDT procedure for RedCap UEs | Huawei, HiSilicon |
| [24] | [R1-2301781](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301781.zip) | On RedCap remaining issues (revision of [R1-2301606](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301606.zip)) | MediaTek Inc. |
| [25] | [R1-2301782](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301782.zip) | Draft CR on validation of PRACH and PUSCH occasions with NCD-SSB (revision of [R1-2301607](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112/Docs/R1-2301607.zip)) | MediaTek Inc. |
| [26] | [R2-2213001](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_120/Docs/R2-2213001.zip) | Report from Break-out session on NR-NTN, IoT-NTN, RedCap, and CE | Vice Chairman (ZTE Corporation) |
| [27] | [R1-2200002](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107b-e/Docs/R1-2200002.zip) | Report of RAN1#107-e meeting | ETSI MCC |
| [28] | [R1-2205193](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2205193.zip) | Report of RAN1#108-e meeting | ETSI MCC |
| [29] | [R2-2202102](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_117-e/Docs/R2-2202102.zip) | RAN2#116bis-e Meeting Report | ETSI MCC |
| [30] | [R1-2210630](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110b-e/Docs/R1-2210630.zip) | 38.214 CR0356 (Rel-17, F) Correction on invalid symbol determination for PUSCH repetition type B for HD-FDD | Moderator (Ericsson), Vivo, Sharp, Intel, Nokia, Nokia Shanghai Bell, Ericsson, Samsung |