3GPP TSG-RAN WG1 Meeting #106-e R1-21xxxxx

e-Meeting, 16th – 27th August 2021

**Agenda Item: 8.6.1.3**

**Title: FL summary #1 on duplex operation for RedCap**

**Source: Moderator (Qualcomm Inc.)**

**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]. Earlier RAN1 agreements for this WI are summarized in [2].

This document summarizes contributions [3] – [26] submitted to agenda item 8.6.1.3 and captures this email discussion on duplex operation for RedCap:

|  |
| --- |
| [106-e-NR-R17-RedCap-03] Email discussion regarding aspects related to duplex operation – Chao (Qualcomm)   * 1st check point: 8/19 * 2nd check point: 8/24 * Final check: 8/27 |

The final FLS from the previous RAN1 meeting can be found in [27].

The issues in this document are tagged and color coded with High Priority or Medium Priority.

# Collision handling for Case 5

RAN1#104bis-e reached the following working assumptions [2]:

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| Working assumption:   * If a dynamically scheduled UL transmission overlaps with an SSB, down-select one of the following options:   + Option 1: Follow the handling of case 2 that dynamic UL is prioritized over SSB   + Option 2: Reuse the existing collision handling principles of Rel-15/16 for NR TDD that SSB is prioritized over dynamic UL   + Option 3: Leave to UE implementation whether to receive the SSB or transmit the UL transmission   + Other options are not precluded * If a semi-static configured UL transmission overlaps with an SSB, down-select from the following options:   + Option 1: Up to gNB configuration to avoid such collision and if it happens it is an error case   + Option 2: Reuse the existing collision handling principles of Rel-15/16 for NR TDD that SSB is prioritized over semi-static UL   + Option 3: Leave to UE implementation whether to receive the SSB or transmit the UL transmission   + Other options are not precluded * FFS: whether/how to account for Tx/Rx switching time before and after the set of SSB symbols * FFS: whether or not the semi-static configured UL transmission includes a valid RO |

## SSB overlaps with dynamically scheduled UL transmission

For the case of SSB overlaps with dynamically scheduled UL transmission, companies’ views are summarized in Table 2.1-1.

**Table 2.1-1: Views on collision handling for SSB overlaps with dynamically scheduled UL transmission**

|  |  |  |  |
| --- | --- | --- | --- |
| Index | Description | Companies | # of Companies |
| Option 1 | Follow the handling of case 2 that dynamic UL is prioritized over SSB | Ericsson, vivo, Nokia, CATT, China Telecom, CMCC, ASUSTeK (1st choice), WILUS | 8 |
| Option 2 | Reuse the existing collision handling principles of Rel-15/16 for NR TDD that SSB is prioritized over dynamic UL | Spreadtrum (2nd choice), Samsung (2nd choice), NordicSemi, OPPO, QC, LG, Intel, Apple, DoCoMo, Xiaomi (2nd choice), Panasonic, ASUSTeK (2nd choice) | 12 |
| Option 3 | Leave to UE implementation whether to receive the SSB or transmit the UL transmission | Spreadtrum (1st choice), Samsung (1st choice), Apple (2nd choice), Xiaomi (1st choice) | 4 |

Another option that differentiates Msg3 or Msg3 re-transmission with other dynamically scheduled UL transmission was proposed in contribution [ZTE08]. That is, if the dynamically scheduled UL transmission happens during RA procedure, the dynamically scheduled UL transmission is prioritized; otherwise, the SSB reception is prioritized.

From the above, Option 1 and 2 receives relatively more support. Specific comments regarding benefits, advantages, drawbacks, concerns and impacts for each of the options in the RAN1#104bis-e agreement are summarized below.

**Option 1: dynamic UL is prioritized over SSB**

Benefits/advantages:

* Additional flexibility for scheduler and is consistent with principle of dynamic scheduling [Ericsson04, CATT10]
* With this option, gNB can still avoid scheduling UL overlapping with SSB [Ericsson04]

Drawbacks/concerns/impacts:

* Will have impact on time and frequency tracking loop at the UE side since UE [ZTE08, Apple19]
* UE may not be able to monitor the overlapped SSB and meet RAN4 RRM timeline [Qualcomm14]
* Risk of introducing more complicated rule for multiplexing between UL channels if different collision handling rules are considered for dynamic and semi-static UL [Samsung09]

**Option 2: SSB is prioritized over dynamic UL**

Benefits/advantages:

* Minimum spec change [Xiaomi23, Spreadtrum07]

Drawbacks/concerns/impacts:

* Lack of flexibility [Ericsson04]

**Option 3: Leave to UE implementation**

Benefits/advantages:

* UE can make the decision based on RRM measurement implementation [Apple19]

Drawbacks/concerns/impacts:

* Increased detection complexity at gNB [vivo05]

**FL1 High Priority Question 2.1-1:**

* **Companies are invited to comment whether and what additional speficiation work are needed to adress the potential risk or concern for each option in the above, in particular regarding whether it is necessary to consider a unified solution to handle all the subcases of Case 5?**

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| **Company** | **Y/N** | **Comments** |
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Contribution [Qualcomm14] proposed that PDCCH ordered PRACH should be excluded from the dynamically scheduled UL transmission since it is considered in Case 8, while contribution [vivo05] has a different view that the dynamically scheduled UL transmission includes PUSCH, PUCCH, SRS and PRACH triggered by PDCCH order.

**FL1 High Priority Question 2.1-2:**

* **For Case 5 of SSB overlapping with dynamically scheduled UL transmission, should PRACH triggered by PDCCH order be considered also?**

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| **Company** | **Y/N** | **Comments** |
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## SSB overlaps with configured UL transmission

For the case of SSB overlaps with semi-statically configured UL transmission, companies’ positions are summarized in Table 2.2-1.

**Table 2.2-1: View on collision handling for SSB overlaps with semi-statically configured UL transmission**

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| --- | --- | --- | --- |
| Index | Description | Companies | # of Companies |
| Option 1 | Up to gNB configuration to avoid such collision and if it happens it is an error case |  |  |
| Option 2 | Reuse the existing collision handling principles of Rel-15/16 for NR TDD that SSB is prioritized over semi-static UL | Ericsson, vivo, Spreadtrum (2nd choice), ZTE, Samsung (2nd choice), CATT, NordicSemi, China Telecom, OPPO, QC, CMCC, LG, Apple, DCM, Xiaomi (2nd choice), Panasonic, ASUSTeK, WILUS | 18 |
| Option 3 | Leave to UE implementation whether to receive the SSB or transmit the UL transmission | vivo, SPREADTRUM (1st choice), Samsung (1st choice), Apple (2nd choice), Xiaomi (1st choice) | 5 |

Another two new options are also presented by some companies.

* Contribution [Nokia06] considers a combination of Options 1 and 3. That is, it is up to gNB configuration to avoid such collision. However, if collision occurs, it is up to UE implementation whether to receive the SSB or to transmit on the uplink
* Contribution [Intel18] presents a new option to differentiate CG-PUSCH from other configured UL transmission, i.e., using Option 3 for CG-PUSCH and Option 2 for configured UL transmission other than CG PUSCH.

In contribution [Ericsson03], it is viewed that Option 3 may lead to increased gNB decoding of UL transmission, and a modified version of Option 3 is proposed, i.e., leave it to UE implementation whether to receive the SSB or transmit the UL transmission based on the RRM requirement of the UE.

Views regarding whether the semi-static configured UL transmission includes a valid RO are summarized as following:

* Contributions [vivo05, ZTE08, Qualcomm14] clarify that the configured UL transmission includes PUSCH, PUCCH and SRS but not PRACH
* Contribution [LG16] views that the semi-static configured UL transmission also includes a valid RO and a valid PUSCH occasion for 2-step RACH

From the above, Option 2 receives the majority support. It is noted that most companies supporting Option 3 also consider Option 2 as a secondary preferred solution.

Regarding whether the semi-static configured UL transmission includes a valid RO and/or a valid PUSCH occasion for 2-step RACH, the FL suggestion is to further discuss it in Case 8 to avoid the overlapping discussion.

**FL1 High Priority Proposal 2.2-1:**

* **For Case 5 of SSB overlaps with configured UL transmission, re-use the existing collision handling principles of Rel-15/16 for NR TDD that configured SSB is prioritized over configured UL**
  + **The configured UL transmission may include CG-PUSCH, PUCCH or SRS**

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| **Company** | **Y/N** | **Comments** |
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## Whether to account for Tx/Rx switching time before and after the set of SSB symbols

An FFS identified in RAN1#104bis-e for Case 5 is whether the Tx/Rx switching time should be accounted before and after the set of SSB symbols.

* In contribution [Ericsson04], it is viewed that if the UE behavior for Case 9 is clarified to ensure that Tx/Rx switching time is fulfilled, there is no need to further account for the Tx/Rx switching time under Case 5
* Contributions [Vivo05, Apple19] express view that gNB should ensure the sufficient Tx/Rx switching time before and after the set of SSB symbols and no special handling is needed
* Contribution [ZTE08] presents that Tx/Rx switching time should be considered for SSB overlapped with UL when determining the collision handling rules
* Contribution [Samsung09] indicates that the TX/RX switching time should be considered for SRS overlapped with SSB since SRS can be transmitted before and/or after the set of SSB symbols is received
* Contribution [LG16] has expressed view that the Rx-to-Tx switching time after the set of SSB symbol should be accounted for HD-FDD operation in FDD bands

From the above, the views are split. A common question is whether the back-to-back (without sufficient gap) scenarios can be avoided by gNB, and if not, whether the WA for Case 9 is sufficient to handle the collision, e.g., treating it as an error case. Contribution [ZTE] concerns that reception of SSB may not be successful for the case of SSB immediately following the last symbol of UL transmission without sufficient time gap.

Considering this may be coupled with the discussion for Case 9, the FL suggests we come back to this FFS after Case 9 has been discussed clearly.

# Collision handling for Case 8

## PRACH occasion validation for HD-FDD UEs

For the definition of “valid RO” for HD-FDD UEs, the following options are discussed in RAN1#105-e meeting:

* Option 1: Same as NR FDD that all PRACH occasions are valid
* Option 2: Similar to NR TDD that a PRACH occasion in a PRACH slot is valid if it does not precede a SS/PBCH block in the PRACH slot and starts at least Ngap symbols after a last SS/PBCH block symbol

Table 3.1-1 summarizes the companies view for the above two options

**Table 3.1-1: Views on RO validation for HD-FDD UEs**

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| --- | --- | --- | --- |
| Index | Description | Companies | # of Companies |
| Option 1 | FDD definition | Huawei, Ericsson, vivo, Nokia, ZTE, Samsung, CATT, CMCC, MTK, Intel, Apple, DCM, Xiaomi, Panasonic | 14 |
| Option 2 | TDD definition | OPPO, LG, WILUS, Qualcomm | 4 |

Specific comments regarding benefits, advantages, drawbacks, concerns and impacts for each of the options are summarized in the following table below.

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| --- | --- | --- |
|  | FDD validitation rule | TDD validation rule |
| gNB impacts | Support sharing ROs b/w FD-FDD and HD-FDD UEs with consistent SSB-to-RO mapping | Mismatch on SSB-to-RO mapping between FD-UD and HD-UE thus potentially increasing gNB complexity for PRACH detection |
| HD-FDD UE impacts | Increased RACH latency  May not be able to transmit on the ROs associated with the best SSB beams due to persistent collision  May not be able to meet performance requirements for RRM measurements if valid RO is prioritized | All valid ROs can be used for PRACH transmission |
| Spec. impacts | Need to specify collision handling rule for SSB vs. valid RO | Need to support configuration of dedicated PRACH resources to HD-FDD UEs |

Contribution [NordicSemi11] presents a new option to address the SSB-to-RO mapping issue by mapping the transmitted SSBs to all PRACH occasions irrespective whether they are valid or not when the TDD rule is reused for HD-FDD.

In Contribution [Huawei01], it is proposed that not only the RO validation but also the PO validation and the RO/Po-to-PRU mapping rules of HD-FDD UEs should follow the rules of FDD’s definition.

For Option 1, there is the case of SSB colliding with valid ROs and the following alternatives are discussed in the contributions

* Alt. 1: Leave it to UE whether to receive SSB or transmit PRACH (e.g., based on RRM requirement)
* Alt. 2: Prioritize only the valid RO used for PRACH transmission; otherwise, SSB reception is prioritized
* Alt. 3: Always prioritize either SSB or RO

Contributions [Ericsson04, vivo05, Nokia06, CATT10, CT12, MTK17, Intel18, Apple19, IDCC21, DCM22, Panasonic24] support Alt. 1 since it provides flexibility and does not expect to cause an impact on gNB operation.

Alt. 2 is considered in contribution [ZTE08] since it is noted that the collision between the valid RO and SSB does not exist if a valid RO is not used for preamble transmission.

**FL1 High Priority Question 3.1-1:**

* **In order to facilitate a converged understanding, companies are invited to comment on the benefits and drawbacks for both Option 1 and 2, in particular regarding how each option can be designed to overcome/minimize the identified drawbacks of the option**

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| **Company** | **Y/N** | **Comments** |
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## valid RO overlaps with PDCCH in Type 0/0A/1/2 CSS set

From RAN1 #105-e [2] ,the following agreements were reached for this collision sub-cases:

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| Agreement:   * For Case 8 of valid RO overlapping with PDCCH in Type 0/0A/1/2 CSS set, down-select from the following options   + Option 1: Reuse the existing collision handling principles of Rel-15/16 for NR TDD that valid RO is prioritized over configured PDCCH   + Option 2: Leave to UE implementation whether to receive the configured PDCCH or transmit the PRACH on the valid RO   + Option 3: If configured PDCCH is in a Type-2 CSS set, then PDCCH is prioritized; otherwise the valid RO is prioritized   + Option 4: Configured PDCCH is prioritized over valid RO   + Option 5: Configured by network, e.g. via a priority indicator   + FFS: whether or not the set of symbols overlapping with PDCCH in CSS set includes also Ngap symbols before the valid RO and whether the same value for Ngap in current spec is reused for HD-FDD   + FFS whether a valid RO follows TDD’s or FDD’s definition, and if so, the corresponding impact * FFS: whether or not the same principle is applied to PUSCH occasion of MSGA in 2-step RACH, if supported |

Table 3.2-1 summarizes the companies view for the 5 options in RAN1#105-e agreement.

**Table 3.2-1: Views on collision handling for valid RO overlaps with PDCCH in Type 0/0A/1/2 CSS set**

|  |  |  |  |
| --- | --- | --- | --- |
| Index | Description | Companies | # of Companies |
| Option 1 | Reuse the existing collision handling principles of Rel-15/16 for NR TDD that valid RO is prioritized over configured PDCCH | Ericsson (1st choice), Spreadtrum (2nd choice), NordicSemi, OPPO, LG, Apple, Sharp, IDCC, DCM, Panasonic, ASUSTeK, WILUS | 12 |
| Option 2 | Leave to UE implementation whether to receive the configured PDCCH or transmit the PRACH on the valid RO | Huawei, Ericsson (2nd choice), Nokia, Spreadtrum (1st choice), Samsung, CATT, QC, CMCC, MTK, Intel, Xiaomi | 11 |
| Option 3 | If configured PDCCH is in a Type-2 CSS set, then PDCCH is prioritized; otherwise, the valid RO is prioritized | vivo |  |
| Option 4 | Configured PDCCH is prioritized over valid RO |  |  |
| Option 5 | Configured by network, e.g., via a priority indicator |  |  |

In contribution [ZTE08], it is noted that if a valid RO is not used for preamble transmission, the collision between the valid RO and dynamically scheduled DL does not exist. Therefore, it is suggested to differentiate the collision handling for the valid RO based on whether it has been selected by the UE for preamble transmission, and for the ROs not intended for preamble transmission, the collision handling rules can be defined per CSS set.

In contributions [Ericsson04, Samsung09, Apple19], it is suggested to consider a unified solution to handle all the sub-cases under Case 8 to minimize the specification impact as well as simplify the collision handling operation.

Contribution [vivo05] argues that Option 3 can achieve better trade-off among prioritizing random access, reception of important downlink signalling and UE complexity. Contribution [OPPO13] views that Type 2 CSS set overlapping with valid RO happens less frequently and the network can ensure the paging to HD-FDD UE not to be sent in a RO slot.

From the above, a common question is whether to define the priority rule per CSS set. Also, it is noted that in the following agreement for Case 2, the PRACH triggered by PDCCH order has a higher priority than the semi-statically configured DL reception (including PDCCH in CSS set). Therefore, it needs to be clarified whether the valid RO in this collision subcase include the RO associated with PRACH triggered by PDCCH order.

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| Agreements:   * For Case 2 (semi-statically configured DL reception vs. dynamically scheduled UL transmission), reuse the existing collision handling principles in Rel-15/16 NR for operation on a single carrier/single cell in unpaired spectrum   + The semi-statically configured DL reception may include PDCCH (excluding ULCI), SPS PDSCH, CSI-RS or PRS.     - FFS on PDCCH carrying ULCI, including whether or not it is supported by RedCap UEs (including potential difference between HD vs. FD RedCap UEs)   + The dynamically scheduled UL transmission may include PUSCH, PUCCH, SRS or PRACH triggered by PDCCH order   Agreements:   * For Case 2 (semi-statically configured DL reception vs. dynamically scheduled UL transmission), a HD-FDD RedCap UE is not required to monitor ULCI   + No special handling on the priority rule for PDCCH carrying ULCI |

**FL1 High Priority Question 3.2-1:**

* **For Case 8 of valid RO overlapping with PDCCH in Type 0/0A/1/2 CSS set, should RAN1 consider to define the pirority rule per CSS set? Companies are invited to comment whehter the valid RO in this collision subcase should include the RO associated with PRACH triggered by PDCCH order.**

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| **Company** | **Y/N** | **Comments** |
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## valid RO overlaps with UE-dedicated configured DL reception

From RAN1 #105-e [2] ,the following agreements were reached for this collision sub-cases. There are 3 options in the agreements and other options are not precluded

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| Agreement:   * For Case 8 of valid RO overlapping with UE-dedicated configured DL reception (e.g. PDCCH in USS, SPS PDSCH, CSI-RS or DL PRS), down-select from the following options   + Option 1: Reuse the existing collision handling principles of Rel-15/16 for NR TDD that valid RO is prioritized over configured DL   + Option 2: Leave to UE implementation whether to receive the configured DL or transmit the PRACH on the valid RO   + Option 5: Configured by network, e.g. via a priority indicator   + Other options are not precluded.   + FFS: whether or not the set of symbols overlapping with configured DL includes also Ngap symbols before the valid RO and whether the same value for Ngap in current spec is reused for HD-FDD * FFS: whether or not the same principle is applied to PUSCH occasion of MSGA in 2-step RACH, if supported |

Table 3.3-1 summarizes the companies’ views for the 3 options in RAN1#105-e agreements.

**Table 3.3-1: Views on collision handling for valid RO overlaps with UE-dedicated configured DL reception**

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| --- | --- | --- | --- |
| Index | Description | Companies | # of Companies |
| Option 1 | Reuse the existing collision handling principles of Rel-15/16 for NR TDD that valid RO is prioritized over configured DL | Ericsson, Spreadtrum (2nd choice), CATT, NordicSemi, OPPO, CMCC, LG, Apple, Sharp, IDCC, DCM, Panasonic, ASUSTeK | 13 |
| Option 2 | Leave to UE implementation whether to receive the configured DL or transmit the PRACH on the valid RO | Nokia, Spreadtrum (1st choice), Samsung, MTK, Intel, Xiaomi | 6 |
| Option 5 | Configured by network, e.g. via a priority indicator | Huawei | 1 |

In contribution [ZTE08], it is noted that if a valid RO is not used for preamble transmission, the collision between the valid RO and dynamically scheduled DL does not exist. Therefore, it is suggested to support Option 1 but only for the valid ROs on which UE intends to send preamble

Contribution [vivo05] argues that all the three options in the RAN#105-e agreement have some issues and proposes another two options for down-selection with a slight preference for Option 4.

* Option 3: UE-dedicated configured DL reception is prioritized over the valid RO
* Option 4: Treated as a configuration error of NW (error case)

Contributions [CT12, QC14] express a similar view that the collision handling for this subcase can follow the handling of Case 3, i.e., the overlapping between valid RO and UE-dedicated configured DL reception is not expected by UE and will be treated as a configuration error.

From the above, there is a clear majority view for Option 1. The main concern for Option 2 is the ambiguity exist between the gNB and UE and thus the gNB complexity may also increase unnecessarily. Regarding the new option 4, based on the FL understanding, there is no essential difference compared to option 1. Both options may require the network not to configure the UE-dedicated configured DL reception in the valid RO slots, except that one is soft restriction (i.e., Option 1) and the other is hard restriction (i.e., Option 4).

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**FL1 High Priority Proposal 3.3-1:**

* **For Case 8 of valid RO overlapping with UE-dedicated configured DL reception (e.g. PDCCH in USS, SPS PDSCH, CSI-RS or DL PRS), valid RO is prioritized over UE-dedicated configured DL reception (same as TDD case)**

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| **Company** | **Y/N** | **Comments** |
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## valid RO overlaps with dynamically scheduled DL reception

From RAN1 #105-e [2] ,the following agreements were reached for this collision sub-cases:

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| --- |
| Agreement:   * For Case 8 of valid RO overlapping with dynamically scheduled DL reception, down-select from the following options   + Option 1: Reuse the existing collision handling principles of Rel-15/16 for NR TDD for operation on a single carrier /single cell in unpaired spectrum   + Option 2: Leave to UE implementation whether to receive the DL or transmit the PRACH on a valid RO   + Option 3: Follow the handling of Case 1 that when the cancellation timeline is satisfied, the UE cancels the PRACH transmission and receives the DL signal/channels on the symbols overlapping with PRACH occasion (Interpretation 2 in R1-2103809)   + Option 4: Valid RO is prioritized over dynamic DL that UE performs PRACH transmission and does not perform the DL receptions (Interpretation 3 in R1-2103809)   + Option 5: When the cancellation timeline is satisfied, the UE neither performs transmission nor receives any DL signal/channels on the symbols overlapping with PRACH occasion (Interpretation 1 in R1-2103809)   + FFS: whether or not the set of symbols overlapping with dynamic DL reception includes also Ngap symbols before the valid RO and whether the same value for Ngap in current spec is reused for HD-FDD * FFS: whether or not the same principle is applied to PUSCH occasion of MSGA in 2-step RACH, if supported |

Table 3.4-1 summarizes the companies view for the above 5 options in RAN1#105-e agreement.

**Table 3.4-1: Views on collision handling for valid RO overlaps with dynamically scheduled DL reception**

|  |  |  |  |
| --- | --- | --- | --- |
| Index | Description | Companies | # of Companies |
| Option 1 | Reuse the existing collision handling principles of Rel-15/16 for NR TDD for operation on a single carrier /single cell in unpaired spectrum | OPPO, LG, Apple, IDCC | 4 |
| Option 2 | Leave to UE implementation whether to receive the DL or transmit the PRACH on a valid RO | Nokia, Spreadtrum (1st choice), Samsung, MTK, Xiaomi | 5 |
| Option 3 | When the cancellation timeline is satisfied, the UE cancels the PRACH transmission and receives the DL signal/channels on the symbols overlapping with PRACH occasion (Interpretation 2 in R1-2103809) | Huawei, vivo, CATT, China Telecom, MTK, Sharp, ASUSTeK | 7 |
| Option 4 | Valid RO is prioritized over dynamic DL that UE performs PRACH transmission and does not perform the DL receptions (Interpretation 3 in R1-2103809) | Ericsson, Spreadtrum (2nd choice), NordicSemi, CMCC, Intel, DCM, Panasonic | 7 |
| Option 5 | When the cancellation timeline is satisfied, the UE neither performs transmission nor receives any DL signal/channels on the symbols overlapping with PRACH occasion (Interpretation 1 in R1-2103809) | Spreadtrum (2nd choice) | 1 |

The views on the above 5 options in the RAN1#105-e agreement are split.

* Contribution [Ericsson] indicates that a clarification may be needed for Option 3 and 5 for a UE capable of partial UL cancellation and Option 4 is viewed as the cleanest solution among all the options
* Contribution [vivo05] views that option 2 is not desirable since the ambiguity may exist between the gNB and UE, and option 5 resolves the UE behaviour ambiguity but it is not clear what is the motivation for such UE behaviour since the UE loses both PRACH transmission opportunity and DL receptions
* Contribution [Nokia06] presents that UE should prioritize valid RO over dynamically scheduled DL reception if UE needs to transmit PRACH in case of valid RO overlapping with dynamically scheduled DL reception
* In contribution [ZTE08], it is noted that if a valid RO is not used for preamble transmission, the collision between the valid RO and dynamically scheduled DL does not exist, and thus it is suggested to support Option 1 but only for the valid ROs on which UE intends to send preamble
* Contribution [MTK17] indicates that Option 4 and 5 are not meaningful and the optimization achieved by Option 2 is minor
* In contribution [Qualcomm14], it is proposed that the overlapping between valid RO and dynamically scheduled DL reception is not expected by UE and will be treated as a configuration error of NW
* Contributions [Samsung09, Apple19] suggest supporting the same collision handling rule for all the sub-cases in order to avoid creating another complicated scenario, instead of case-by-case optimization
* In contribution [Sharp20], it is noted that the DL reception should be canceled for a TDD cell if the two rules are applied to the same set of symbols, but for a FDD cell and HD-FDD UEs, Option 3 may be the only interpretation of the wording in the specification
* Contribution [IDCC21] views that according to the spec, the UE does not receive the DL transmission and also cancels the UL transmission as timeline allows
* Contribution [Xiaomi23] notes that gNB cannot predict when UE will use the valid RO opportunity for UL transmission and considering gNB can anyway simultaneously transmit DL and do PRACH detection it is preferred to solve the UL/DL collision issue of valid RO by UE implementation
* Contribution [ASUSTeK25] discusses that for scenario that valid RO overlapping with more than one subcase of DL receptions, an identical collision handling rule can be applied

From the above, Option 5 has the minimum number of supports compared to other options thus can be deleted for down-selection. For Option 3 and Option 4, the difference is whether to allow UE to perform full cancellation of PRACH transmission when timeline is satisfied or partial PRACH cancellation when time is not satisfied (i.e., for a UE capable of partial UL cancellation). Option 4 is relatively easier for implementation since the valid RO is always prioritized over dynamically scheduled DL reception, but UE may lose the possibility to receive any DL signal/channels on the symbols overlapping with PRACH occasion.

**FL1 High Priority Question 3.4-1:**

* **Companies are invited to comment whether the conditional PRACH cancellation (fully or partially) will lead to increased UE implementation complexity, and whether it is necessary to support the same collision handling rule for all the subcases under Case 8?**

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| **Company** | **Y/N** | **Comments** |
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## Whether or not Ngap symbols before the valid RO is included

**FFS: whether or not the set of symbols overlapping with dynamic DL reception includes also Ngap symbols before the valid RO and whether the same value for Ngap in current spec is reused for HD-FDD**

* Contributions [Ericsson04, CATT10] express view that Ngap symbols is accounted for in the collision handling related to valid RO since it can be utilized as the Rx/Tx swithcing time and the same value for Ngap for unpaired spectrum in the current specification is reused for HD-FDD
* In contribution [Samsung09], it is discussed that if Ngap symbols are specified for HD-FDD UEs, it can be utilized as the RX/TX switching time. Otherwise, the RX/TX switching time can be additionally considered
* In contribution [vivo05], it is discussed that for the collision subcases where DL reception is cell-specifically configured, including Ngap symbols before the valid RO may be beneficial to account for the DL-to-UL switching time, but for collision case where DL reception is dynamically scheduled or dedicatedly configured, including Ngap symbols before the valid RO is not necessary
* Contribution [LG16] indicates that the Rx-to-Tx switching time before the valid RO needs to be accounted for all the subcases of Case 8 and proposes FFS on whether the Ngap symbols before the valid RO already covers the Rx-to-Tx switching time.
* Contribution [Nokia06] presents that the set of symbols overlapping with dynamic DL reception does not include the Ngap symbols before the valid RO

From the above, the majority view is that the Rx/Tx switching time before the valid RO needs to be accounted at least for the collision subcases where DL reception is cell-specifically configured. Dependent on whether Ngap symbols are specified for HD-FDD UEs (i.e., according to the RO validation discussion in section 3.1), specification work can be different.

**FL1 High Priority Question 3.5-1:**

* **Should RAN1 consider to use the Ngap symbols before the valid RO to account for the DL-to-UL switching time? If yes, comapnies are invited to commen whether the same value for Ngap for unpaired spectrum in the current specification (Table 8.1-2 in TS 38.213) can be reused for HD-FDD?**

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| **Company** | **Y/N** | **Comments** |
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## Whether or not the same principle is applied to PUSCH occasion of MsgA in 2-step RACH, if supported

In contribution [Ericsson04], it is proposed not to have special treatment for PUSCH occasion of Msg A, i.e., the collision handling rule is the same as other configured PUSCH since the 2-step RACH can fallback to the 4-step RACH, e.g., when RA preamble is detected but PUSCH is not received.

Contributions [CATT10, MTK17] view that the handling of MsgA PUSCH follows the handling of valid RO

Contribution [Nokia06] proposes to prioritize MsgA PUSCH over dynamic or semi-static DL.

In contribution [Intel18], it is discussed that when a MsgA PUSCH is overlapped with a dynamically scheduled DL reception, the MsgA PUSCH is cancelled if the cancellation time for MsgA PUSCH is met (overlap handling Case 1); and when a MsgA PUSCH is overlapped with a configured DL reception, the MsgA PUSCH is cancelled.

Considering this may be coupled with the discussion of collision handling rule for valid RO, the FL suggests we come back to this issue after the collision handling for valid RO has been discussed clearly.

# Collision handling for Case 9

RAN1#104bis-e reached the following working assumptions [2]:

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| Working assumption:   * For HD-FDD, reuse the same principle as Rel-15/16 UE not capable of full-duplex communication   + A HD-FDD UE is not expected to transmit in the uplink earlier than [*NRX-TX Tc*] after the end of the last received downlink symbol in the same cell   + A HD-FDD UE is not expected to receive in the downlink earlier than [*NTX-RX Tc*] after the end of the last transmitted uplink symbol in the same cell   + FFS NTX-RX and NRX-TX   + FFS: how it jointly works with the agreement for other collision cases |

Regarding the second FFS in the above agreement, the following are discussed in the contributions:

Contribution [Nokia06, CT12, Apple19] view that the concerned collision due to DL/UL direction switching can be handled by gNB, i.e., scheduling the back-to-back DL-to-UL and UL-to-DL transmission and reception with the necessary gaps.

In contribution [Sharp20] it is also suggested to define adequate Tx/Rx switching time for HD-FDD UEs.

In contribution [vivo05], it is viewed that for back-to-back transmission/reception configured by cell-specific higher layer parameters, given the proposal that the Ngap symbols have been included in valid RO, hence the handling of direction switching can be the same as the collision case and a separate rule is not needed. For other cases, the gNB scheduler should ensure the switching time.

Contribution [Ericsson04] views that the collision with the switching time after applying collision handling rules can occur since it may be difficult for gNB scheduler to avoid the immediate back-to-back (without sufficient gap) scenarios for cases involving semi-statically configured DL/UL (including both UE specific and cell specific). If it is interpreted as an error case, excessive restrictions will be imposed on network configuration. Two options are proposed for further discussion.

* Option 1: An earlier DL reception or UL transmission is prioritized by puncturing or skipping first few symbols of the later UL transmission or DL reception
* Option 2: Leave it to UE implementation to ensure the switching time is satisfied

Contributions [Xiaomi23, Intel18] also raise concern for treating it as an error case if the switching time is not enough after applying the collision handling rule and suggest further discussion for the following two alternatives

* Alt. 1: Treat it as an error case
* Alt. 2: Consider it as an UL/DL collision and apply the associated collision handling rule defined in other cases

In contribution [ZTE08], it is discussed that the “last received downlink symbol” or “last transmitted uplink symbol” in this WA may not be equivalent to “last scheduled/configured” downlink or uplink symbol and thus any collision handling rule defined in Case1~Case 8 should follow the restriction defined in Case 9.

**FL1 High Priority Question 4-1:**

* **Shall RAN1 discuss the case when gNB cannot ensure the sufficient gap when scheduling or configureing a back-to-back DL-to-UL and UL-to-DL transmission and reception, in particular regarding whether UE behaviour in suh case should be specified?**

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| **Company** | **Y/N** | **Comments** |
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# Other aspects (medium priority)

## Whether to define the guard times in symbol units

RAN1#104e made the following agreements related to switching time [2]:

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| Agreements:   * (Working assumption) For HD-FDD switching time, reuse existing switching times for UE not capable of full duplex in TS 38.211, Table 4.3.2-3.   + FFS: whether to define the guard times in symbol units   + FFS: the switching positions * Sending an LS to RAN4 to inform the above working assumption, and to ask for feedback if any   + The LS will not include the two FFS bullets   Draft LS in [R1-2102094](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Inbox/R1-2102094.zip) is approved. Final LS to be uploaded/updated depending on whether or not there are additional agreements for RedCap related to RAN4. Final LS in [R1-2102146](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Inbox/R1-2102146.zip) |

RAN1#104bis-e reached the following WA regarding the second FFS [2]:

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| Working assumption:   * For HD-FDD, no additional UE behavior for switching position determination is specified as compared to the existing specification. |

In [Ericsson04, vivo05, Nokia06, CATT10, CT12], it is suggested to conclude that there is no need to define guard time in symbol units.

Contributions [SPRD07, QC14, WILUS26] prefer to use the symbol-level switching time instead of the actual time unit. It is viewed in contribution [Spreadtrum07, WILUS26] that one OFDM symbol can be defined. Contribution [QC14] discusses that no guard symbol is configured for Tx-to-Rx switching and at least one guard symbols is configured for Rx-to-Tx switching at the UE.

Contribution [LG16] presents that defining the guard time in symbols units can be considered only when we are not reusing the existing switching time (pending confirmation from RAN4).

Considering this may be coupled with the RAN4 feedback about the TX/RX switching time, the FL suggests we come back to this issue after receiving the RAN4 replying LS.

## Case 1: Dynamically scheduled DL reception vs. semi-statically configured UL transmission

RAN1#104bis-e reached the following agreements [2]:

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| Agreements:   * For Case 1 (dynamically scheduled DL reception vs. semi-statically configured UL transmission), reuse the existing collision handling principles in Rel-15/16 NR for operation on a single carrier /single cell in unpaired spectrum.   + FFS whether the timeline is extended to include the RX/TX switching time for HD-FDD |

The remaining FFS is regarding whether the timeline in the above rule should be extended to include the Tx/Rx switching time for HD-FDD.

Contributions [Ericsson04, vivo05, Nokia06, SPRD07, ZTE08, CT12, LG16, Intel18, Apple19, Xiaomi23, WILUS26] express views that there is no need to extend the timeline to include the Tx/Rx switching time since gNB could take into account the switching time when scheduling dynamic DL to avoid collision with the switching time.

Contribution [Ericsson04] also pointed out that if there are still colliding symbols with the switching time after partial cancellation, then the UE behavior to be clarified under Case 9 can be applied [4].



Figure 2 from [4]: In case of UE capable of partial cancellation, gNB can take into account the switching time when scheduling dynamic DL, e.g., schedule a PDSCH after T\_{proc,2} + switching time, to avoid collision with the switching time



Figure 3 from [4]: After partial cancellation of CG PUSCH based on the timeline, there may still be symbols colliding with the switching time. In this case, a UE behavior to be clarified under Case 9 can be applied to ensure that UE does not receive or transmit during the switching time

In contribution [Samsung09], it is proposed to further discuss whether the RX/TX switching time is considered in Case 1 by taking into account the interpretation and also future RAN4 feedback about the RX/TX switching time.

From the above, the great majority view is that there is no need to extend the timeline to include the Tx/Rx switching time in Case 1. Considering the minimum value of Tproc,2 is larger than 5 symbols much larger than the required switching time, the FL suggestion is to make a conclusion without waiting for RAN4 feeedback about the Tx/Rx switching.

**FL1 Medium Priority Proposed Conclusion 5.2-1:**

* **For Case 1 (dynamically scheduled DL reception vs. semi-statically configured UL transmission), there is no need to extend the timeline to include the Tx/Rx switching time.**

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## Case 3: Semi-statically configured DL reception vs. semi-statically configured UL transmission

RAN1#104bis-e reached the following agreements [2]:

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| Agreements:   * For Case 3, semi-statically configured DL reception vs. semi-statically configured UL transmission   + A HD-FDD UE does not expect to receive both dedicated higher layer parameters configuring transmission from the UE in the set of symbols of the slot and dedicated higher layer parameters configuring reception in the set of symbols of the slot   + A HD-FDD UE does not expect to receive both dedicated higher layer parameters configuring transmission from the UE in the set of symbols of the slot and cell specific higher layer parameters configuring reception in the set of symbols of the slot   + A HD-FDD UE does not expect to receive both cell specific higher layer parameters configuring transmission from the UE in the set of symbols of the slot and dedicated higher layer parameters configuring reception in the set of symbols of the slot   + FFS on cell-specifically configured DL reception vs. cell-specifically configured UL transmission   + FFS: whether or not there are conditions that need to be considered |

Some contributions [Ericsson04, vivo05, ZTE08, CT12, Xiaomi23] express views that the agreements for Case 3 may have some overlapping with Case 5 and Case 8 which deal with SSB and valid ROs.

Contributions [Ericsson04, NordicSemi11, Intel18] propose to adopt the following FL proposal in RAN1#104bis-e [4] to revise the RAN1#104bis-e agreements for Case 3.

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| **Proposal 3.3-1: Revise the RAN1#104bis-e agreement for Case 3 as the following**   * For Case 3, semi-statically configured DL reception vs. semi-statically configured UL transmission   + A HD-FDD UE does not expect to receive both dedicated higher layer parameters configuring transmission from the UE in the set of symbols of the slot and dedicated higher layer parameters configuring reception in the set of symbols of the slot   + A HD-FDD UE does not expect to receive both dedicated higher layer parameters configuring transmission from the UE in the set of symbols of the slot and cell specific higher layer parameters configuring reception in the set of symbols of the slot     - Cell-specifically configured DL reception refers to PDCCH in Type-0/0A/[1]/2 CSS set   + ~~A HD-FDD UE does not expect to receive both cell specific higher layer parameters configuring transmission from the UE in the set of symbols of the slot and dedicated higher layer parameters configuring reception in the set of symbols of the slot~~   + ~~FFS on cell-specifically configured DL reception vs. cell-specifically configured UL transmission~~   + FFS: whether or not there are conditions that need to be considered   + Note: Collision handling related to SSB or RO are to be treated in case 5 and case 8. |

According to discussions in RAN1#104bis-e, some companies prefer to make new agreements under Case 5 and 8 instead of revising the previous agreements. Therefore, the FL suggestion is to come back to Case 3 after Case 5 and 8 have been discussed clearly.

For the second FFS in the agreement, contribution [Samsung09] presents two conditions can be further considered. One is to use the SFI to cancel one of the directions. Another is to use a priority indication for collision handling in some cases, e.g., CG-PUSCH with small periodicity overlapping with PDCCH in CSS set.

## Whether SFI can be optionally supported for HD-FDD UE

Regarding whether SFI can be optionally supported for HD-FDD UEs, the following are discussed in a few contributions:

* Contribution [Nokia 06] indicates that there is no need to support dynamic SFI for HD-FDD RedCap UE.
* Contribution [Intel18] raises a potential issue when SFI is supported for HD-FDD UEs. Currently, the DL SFI and UL SFI are separately processed as NR FDD, an open issue is the order to check SFI and to apply overlap handling of a DL reception and a UL transmission since the SFI may cancel certain configured DL reception or UL transmission in the set of overlapped symbols.

## Definition and Identification of HD-FDD UE

One contribution presents view on the UE capability reporting of HD-FDD.

* Contribution [OPPO13] proposes that UE capability of HD-FDD is explicitly defined and to be known by gNB. And the HD-FDD capability of RedCap UE should be identifiable by gNB during the initial access since it may be requested for configuring HARQ-ACK to ensure non-zero gap between the PUCCH and previous DL transmission

# Annex: Companies’ point of contact

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

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| **Company** | **Point of contact** | **Email address** |
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# References

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| [1] | [RP-211574](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_92e/Docs/RP-211574.zip) | Revised WID on support of reduced capability NR devices | Ericsson |
| [2] | [R1-2106213](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2106213.zip) | RAN1 agreements for Rel-17 NR RedCap | Rapporteur (Ericsson) |
| [3] | [R1-2106461](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106461.zip) | Duplex operation for RedCap | Huawei, HiSilicon |
| [4] | [R1-2106565](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106565.zip) | Duplex operation for RedCap | Ericsson |
| [5] | [R1-2106603](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106603.zip) | Discussion on RedCap half-duplex operation | vivo, Guangdong Genius |
| [6] | [R1-2106650](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106650.zip) | UE Complexity Reduction aspects related to duplex operation | Nokia, Nokia Shanghai Bell |
| [7] | [R1-2106706](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106706.zip) | Discussion on duplex operation for RedCap | Spreadtrum Communications |
| [8] | [R1-2106843](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106843.zip) | HD-FDD for reduced capability NR devices | ZTE, Sanechips |
| [9] | [R1-2106896](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106896.zip) | HD-FDD Operation for RedCap UEs | Samsung |
| [10] | [R1-2106979](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106979.zip) | Discussion on HD-FDD operation | CATT |
| [11] | [R1-2107042](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107042.zip) | On aspects related to duplex operation | Nordic Semiconductor ASA |
| [12] | [R1-2107129](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107129.zip) | Discussion on duplex operation for RedCap | China Telecom |
| [13] | [R1-2107251](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107251.zip) | On half-duplex operation | OPPO |
| [14] | [R1-2107353](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107353.zip) | Type-A HD-FDD for RedCap UE | Qualcomm Incorporated |
| [15] | [R1-2107410](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107410.zip) | Discussion on collision handling of HD-FDD operation | CMCC |
| [16] | [R1-2107450](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107450.zip) | Aspects related to the duplex operation of RedCap | LG Electronics |
| [17] | [R1-2107497](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107497.zip) | On half duplex operation for RedCap UEs | MediaTek Inc. |
| [18] | [R1-2107597](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107597.zip) | On HD-FDD support for RedCap | Intel Corporation |
| [19] | [R1-2107748](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107748.zip) | Duplex Operation for Redcap | Apple |
| [20] | [R1-2107796](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107796.zip) | Discussion on the duplex operation of redcap UEs | Sharp |
| [21] | [R1-2107811](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107811.zip) | Duplex operation for RedCap UEs | InterDigital, Inc. |
| [22] | [R1-2107866](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107866.zip) | Discussion on duplex operation for RedCap | NTT DOCOMO, INC. |
| [23] | [R1-2107928](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107928.zip) | Discussion on Half-duplex FDD operation of Redcap UE | Xiaomi |
| [24] | [R1-2108042](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2108042.zip) | Aspects related to duplex operation | Panasonic Corporation |
| [25] | [R1-2108061](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2108061.zip) | Discussion on aspects related to duplex operation | ASUSTeK |
| [26] | [R1-2108155](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2108155.zip) | Discussion on duplex operation for RedCap UE | WILUS Inc. |
| [27] | [R1-2106244](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2106244.zip) | FL summary #3 on duplex operation for RedCap | Moderator (Qualcomm) |
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