**3GPP TSG-RAN WG2 Meeting #114 electronic R2-2xxxxxx**

**Online, May 17-27, 2021**

**Agenda item:** 8.18

**Source:** Huawei, HiSilicon

**Title:** Summary of [AT114-e][031][NR17] UL TX Switching (Huawei)

**Document for:** Discussion and Decision

# 1. Introduction

This document attempts to summarize the following offline discussion.

* [AT114-e][031][NR17] UL TX Switching (Huawei)

Scope: Treat R2-2104718, R2-2104721, R2-2105156, R2-2105157, R2-2106163, R2-2106164, R2-2106165, R2-2105982, R2-2105623, R2-2105626, R2-2105627, R2-210, R2-210, R2-210, R2-210, R2-210, R2-210, R2-210, R2-210,

Start RAN2 discussion, find agreeable points (if any), and and material for an LS out if applicable.

Intended outcome: Report with agreeable points (if any), agreeable LS out if applicable.

Deadline: In time for on-line CB May 24.

Rapporteur suggests companies to provide comments before May 23 UTC 10:00, so that the agreeable part/possible way forwards can be summarized before on-line CB May 24.

# 2. Background

In Rel-16, the mechanisms of UL Tx switching are specified for switching between case 1 and case 2. And it is assumed that only one transmitter can be supported on one carrier and two transmitters can be supported on the other carrier. In Rel-17, RAN4 approved the further enhancements (in RP-210899) to support Tx switching which would be conducted between two carriers which are both capable of 2Tx transmissions, as two transmitters are enabled for more NR bands. To be specific, the R17 Uplink Tx switching enhancements cover the following scenarios:

* 2Tx-2Tx switching between two uplink carriers for SUL and UL CA
* 1Tx-2Tx and 2Tx-2Tx switching between 1 carrier on band A and 2 contiguous aggregated carriers on band B for SUL and UL CA

For the second listed scenario, compared to Rel-16 UL Tx switching where only 1 CC on band B, the main point is there are 2 contiguous aggregated carries on band B, and this is supported for 1Tx-2Tx and 2Tx-2Tx switching. The below table illustrates the detailed scenarios.

Table 1 UL Tx switching scenarios in Rel-16 and Rel-17

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| --- | --- | --- |
| Scenario 0 | R16 1T-2T switching | 1 CC on band A, 1 CC on band B |
| Scenario 1 | R17 1T-2T switching | 1 CC on band A, 2 CCs on band B |
| Scenario 2 | R17 2T-2T switching | 1 CC on band A, 1 CC on band B |
| Scenario 3 | R17 2T-2T switching | 1 CC on band A, 2 CCs on band B |

RAN4 has discussed the requirements for the above scenarios, and agreed CR in R4-2103236. In addition, RAN4 sent LS in R4-2103234/ R2-2104721 to RAN2 to deliver the UE capability and RRC configuration related agreements.

RAN1 also discussed this topic in RAN1 #104bis-e meeting, and made the agreements on the supported ports number for each case in each scenarios. During the RAN1 discussion, companies had different views on if a UE is allowed to report different switching time for 1T-2T switching and 2T-2T switching, so the below question is asked to RAN1 in LS R1-2104137/R2-2104718.

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| For UL Tx switching in a band pair of a band combination, whether or not the switching time reported by a UE for 2Tx-2Tx switching can be different from that reported by the UE for 1Tx-2Tx switching. |

# 3. Discussion

From RAN2 point of view, the UE capability reporting and RRC configuration should be considered. From the contributions submitted in this meeting, the issues and proposals are raised on the following aspects.

1. General UE capability reporting signaling design.

2. How to report RAN4 agreed UE capabilities (related to RF/RRM requirements), e.g. switching time, DL interruptions for UL CA and SUL.

3. How to report UE capabilities related to RAN1 transmission mechanism, e.g. supported switching options for UL CA.

4. RRC signaling configuration, e.g. period location, switching option.

## 3.1 Issue 1: General UE capability reporting signaling design

In Rel-16, a new BC list was introduced for UL Tx switching, i.e. *BandCombinationList-UplinkTxSwitch*. A UE supporting 1T-2T switching should report the corresponding UE capabilities in this BC list but not in legacy Rel-15 BC list, so that the network can derive the UE capabilities used for UL Tx switching from this Rel-16 BC list.

In the following contributions/draft CRs, it is proposed the Rel-16 UE capability reporting structure for UL Tx switching should be reused to report the UE capability supporting Rel-17 UL Tx switching enhancements.

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| R2-2106163 | Proposal 1: A UE supporting R17 UL Tx switching enhancement reports the corresponding UE capability in the UL Tx switching specific BC list (i.e. BandCombinationList-UplinkTxSwitch). |
| R2-2105626 | Summary of change: In 6.3.3, Adding BandCombinationList-UplinkTxSwitch-v17xx to include BandCombination-UplinkTxSwitch-v17xx to report R17 Tx switching capability for UL switching period and DL interruption; |

Rapporteur understands it should be the common understanding from companies that the UE capability supporting Rel-17 UL Tx switching enhancements (e.g. 2T+2T capability to indicate the support of 2-layer MIMO on both bands) should be reported in the band combination list introduced for Rel-16 UL Tx switching, but not in any new introduced BC list or in legacy Rel-15 BC list.

Q1: Do companies agree that **the UE capability supporting Rel-17 UL Tx switching enhancements should be reported in the band combination list introduced for Rel-16 UL Tx switching (i.e. *BandCombinationList-UplinkTxSwitch*)?**

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| --- | --- | --- |
| Company | Agree(Yes/No) | Comments |
| Huawei, HiSilicon | Yes | This should be the basic principle to reuse legacy signalling structure and to reduce signalling overhead. |
| OPPO | Yes with comment | we understand the intention of this Q1 does not exclude the possibility that for a same BC, UE report it in both BC-list for legacy BC and for R16 Tx switching, where for the former one, the reported capability is surely for non-Tx-switching case. |
| vivo | No | We think band pairs (i.e. BandCombinationList-UplinkTxSwitch) for R17 TX switching should be reported, however for the same BC, band pairs of R16 and R17 may be different.  Furthermore, band pair of 1TX -2TX in R17 and band pair of 2TX -2TX in R17 may also be different for the Same BC. So we would like give the below granularity for BandCombination-UplinkTxSwitch-v17xx for the same BC.  BandCombination-UplinkTxSwitch-v17xx ::= SEQUENCE {  supportedBandPairListNR1Tx2TxThree-r17 SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-r17 OPTIONAL,  supportedBandPairListNR2Tx2TxTwo-r17 SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-r17 OPTIONAL,  supportedBandPairListNR2Tx2TxThree-r17 SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-r17 OPTIONAL  }  Or we can send the LS to RAN4 to confirm our understanding. |
| Nokia, Nokia Shanghai Bell | Yes | We always reuse existing signalling if it's possible. If it's not possible, then we consider other ways to extend but that requires case-by-case analysis. So for now, let's wait for RAN1/4 progress and then have a look at this again.  On sending LS to RAN4, we think that's unnecessary on this point: This is about signalling design and RAN4 has no say in that matter. |
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## 3.2 Issue 2: RAN4 defined capabilities

In Rel-16, RAN4 defined the following UE capabilities for EN-DC, SUL and inter-band UL CA cases. So that in RAN2 signalling design, a list of band pair was added to include the following UE capability parameters for each BC, i.e. in *ULTxSwitchingBandPair*.

* UL switching period, reported per band-pair for a given BC
* DL interruption, reported per band per band-pair for a given BC

In the contributions, companies discussed how to report the above UE capabilities for Rel-17 UL Tx switching.

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| R2-2105156 | Proposal 2: Clarify to RAN4, for a given band pair in a BC, whether a UE can report different switching period and DL interruption capability values in the following two cases:   * Case 1: 1Tx-2Tx switching between two uplink carriers and 1Tx-2Tx switching between 1 carrier on Band A and 2 contiguous carriers; * Case 2: 2Tx-2Tx switching between two uplink carriers and 2Tx-2Tx switching between 1 carrier on Band A and 2 contiguous carriers.   Proposal 3: Clarify to RAN4, for a given BC, whether there is restriction that a UE supporting Rel-17 UL Tx switching must support Rel-16 UL Tx switching for at least one band pair in that BC. |
| R2-2106163 | Proposal 2: For R17 2Tx-2Tx switching between two uplink carriers for SUL and UL CA, introduce R17 ULTxSwitchingBandPair like UE capability to report Switching Period and DL interruption in the UL Tx switching BC list, where UE should report 2T+2T capabilities in UL feature sets for the given BC.  Proposal 3: For R17 UL Tx switching between 1 carrier on band A and 2 contiguous aggregated carriers on band B for SUL and UL CA, the UE should report corresponding CA bandwidth class and UL featureSetPerCCs for 2 continuous CCs on band B in the legacy way, in addition  ‐ For 1Tx-2Tx switching, reuse R16 ULTxSwitchingBandPair UE capability to report switching period and DL interruption.  ‐ For 2Tx-2Tx switching, use the R17 ULTxSwitchingBandPair like UE capability to report switching period and DL interruption introduced for 2Tx-2Tx switching between 1 carrier on band A and 1 or 2 carriers on band B.  ‐ On band B, the fallback capability from 2 CCs to 1 CC can be supported in the legacy way. |
| R2-2105623 | Proposal UE should report three new R17 capabilities for TX switching based on supported Tx switching type and carrier number as below:  R17 1TX-2TX switching (Three UL carriers)  R17 2TX-2TX switching (Two UL carriers)  R17 2TX-2TX switching (Three UL carriers) |

R2-2106163 and R2-2105623 proposed to introduce R17 band pair to report 2T-2T switching capabilities. In RAN4 LS, it is clear that the UE should report the two UE capability parameters for Rel-17 UL Tx switching enhancement, i.e. 2T-2T switching, with the same value set and reporting granularity as in Rel-16. However, RAN1 raised a related question that if UE can report different value for 2T-2T switching compared with 1T-2T switching. So it could be safer to wait for RAN4 confirmation on this question before RAN2 decides the detailed signalling design.

**Q2:** On how to report per band-pair UE capability (i.e. UL switching period and DL interruption) for 2T-2T switching, do companies agree to wait for RAN4 answer to the RAN1’s question?

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| Company | Agree(Yes/No) | Comments |
| Huawei, HiSilicon | Yes | We think it is obvious that a UE should report per band-pair capability for 2T-2T and 1T-2T switching in separate places, no matter the values are the same or different. However, as RAN1 already asked related question, we can accept to wait for RAN4 confirmation. |
| OPPO | Yes | Considering the band-pair that support R16/17 Tx switch may not necessarily the same (e.g., some band pairs may only support 1t+2t but not 2t+2t), we share the same view that different band-pair list is useful.  then for a same band-pair supporting both 1t+2t and 2t+2t, whether the reported capability for switching would be the same or different, we tend to wait for R4 conclusion on final decision (although our view is that they can be different, so separate reporting is safer). |
| vivo |  | See answer in Q1. We are ok to send LS to RAN4 to ask their understandings. |
| Nokia, Nokia Shanghai Bell | Yes | Since the question has been asked already, it's best to wait for the answer before proceeding. |
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Furthermore, there are 2 different interpretations on the below RAN4 agreement:

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| For switching time mask related requirements for inter-band SUL and CA (including the length of switching period, location of switching period, transient period and uplink outage due to switching), the same agreements are applied for the scenarios with either one carrier or two contiguous aggregated carriers on band B |

* **Interpretation 1:** the same UE capabilities including length of switching period, DL interruption applies to the scenarios with either 1CC@band B or 2CCs@band B, which means the UE only reports one set of UE capabilities to cover the 2 scenarios for 2T-2T switching. Similarly for 1T-2T switching.
* **Interpretation 2:** a UE may have different capabilities of switching period length and DL interruption to support the scenarios with 1CC@band B or 2CCs@band B. So different sets of UE capacities should be introduced for the 2 scenarios for 2T-2T switching. Similarly for 1T-2T switching.

From company contributions, R2-2106163 propose the R16 UE capability covers 1T-2T switching with either 1CC@band B or 2CCs@band B and the new set of R17 UE capability covers 2T-2T switching with either 1CC@band B or 2CCs@band B based on interpretation 1. R2-2105623 propose to add 3 more sets of R17 UE capabilites to cover the 3 Rel-17 scenarios based on interpretation 2. While R2-2105156 propose to ask further clarifications from RAN4 whether a UE can report different capability values for the scenarios with 1CC@band B or 2CCs@band B in case of 1T-2T switching or 2T-2T switching. Considering there are not so many companies input on this issue, Rapporteur would like to collect company views on whether RAN2 can have common understanding on **Interpretation 1 or Interpretation 2**. If not, LS to RAN4 can be sent for more clarifications.

**Q3:** Do companies agree with **Interpretation 1 or Interpretation 2?** Or **prefer to send LS to RAN4** for clarification**.**

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| Company | Interpretation 1/  Interpretation 2/  LS to RAN4 | Comments |
| Huawei, HiSilicon | Interpretation 1 | Our understanding is the intention of RAN4 agreement is to say the same value of UE capability of UL switching period and DL interruption is applied to 1CC@band B and 2CCs@band B. The motivation to support 2 contiguous CCs on band B for UL Tx switching in this WI is based on the assumption that the 2CCs are sharing the same Tx(s) and it is quite the same as there is only 1 CC on band B, so no/minor extra standard effort to be required for the scenarios with 2CCs@band B.  And if companies have some concerns, it could be raised in this RAN4 meeting, as RAN4 will discuss RAN1 LS, and we could receive the RAN4 views sooner when RAN4 replies RAN1 LS. |
| OPPO | Interpretation 1 |  |
| vivo |  | We are ok with interpretation 1 or interoperation 2. For safe, the finer granularity of RRC signalling is better, we also would like to send LS to RAN4 to ask their understanding. If RAN4 goes to interpretation 1 we can reduce some UE capability report signalling. |
| Nokia, Nokia Shanghai Bell |  | It seems RAN4 is still discussing this so we can wait for their feedback. |
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Note that R2-2105156 also propose to ask clarification from RAN4 on whether a UE can support different “power boosting” capabilities for different supported UL Tx switching scenarios (e.g. 2-carriers or 3-carriers, 1Tx-2Tx or 2Tx-2Tx). It is observed that RAN4 did not agree to introduce “power boosting” in Rel-17, and company may already have submitted contribution in RAN4 on this issue. Considering this point is totally in RAN4 scope, it should let RAN4 decide if it can be supported or not first. For the time being RAN2 can wait for more RAN4 progress, so no RAN2 action is proposed on this point.

## 3.3 Issue 3: RAN1 defined capabilities

In Rel-16, RAN1 defined different UL transmission mechanisms called option1 and option2 for UL CA case, and introduced a UE capability to report UE can support option1, option2 or both in *uplinkTxSwitching-OptionSupport*. In Rel-17 WID the similar two options are included, and the detailed UE behaviour for the two options are still under-discussion in RAN1.

In R2-2105982/ R2-2105156/ R2-2105623, it is assumed the supported option should be reported for Rel-17 UL Tx switching, however there is diverse views on whether a UE can report different values for 2T-2T switching and 1T-2T switching. For instance, R2-2105982 proposed the UE indicates support of a Re-17 UL Tx switching option, the UE shall also support the corresponding option of Rel-16 UL Tx switching. R2-2105623 proposed the supported option should be reported separately for the new 3 Rel-17 scenarios which seems imply different values are allowed. And R2-2105156 suggest to ask clarification from RAN4.

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| R2-2105156 | Proposal 1: Clarify to RAN4, for a given BC, whether a UE can support different “UL Tx switching option” and “power boosting” capabilities for different supported UL Tx switching scenarios (e.g. 2-carriers or 3-carriers, 1Tx-2Tx or 2Tx-2Tx). |
| R2-2105982 | Proposal 1 For a band combination where the UE indicates support of a Re-17 UL Tx switching option, the UE shall also support the corresponding option of Rel-16 UL Tx switching within this band combination.  Proposal 2 Wait for general Rel-17 UE capability discussion, which should involve UL TX switching, before further progress on the UE capability design for UL TX switching. |
| R2-2105623 | Observation1: Comparing with R16, R17 TX switching also supports both Swiched UL mode(Option 1) and dual UL modes(option 2).  Proposal UL Tx Switching Band Pair and uplink Tx Switching-Option can be reported per three new R17 capabilities for R17 TX switching per band combination. |

Rapporteur understands this issue is only related to RAN1 but not RAN4, as the detailed mechanisms for option1 and option2 are to be defined by RAN1. From RF/RRM requirement perspective, there is no difference between option1 and option2. So a LS to RAN1 (but not RAN4) for clarification maybe one way to go. On the other hand, RAN2 can first wait for more RAN1 progress, as once the UE behaviour captured by RAN1 is clear, it would be clearer if there is dependency between 1T-2T and 2T-2T switching. And if we ask now, RAN1 may just suspend the reply until they finish the CR drafting.

**Q4: which options do companies prefer to handle the capability of supported switching option for Rel-17 UL Tx switching in UL CA case?**

Option 1: wait for RAN1 progress

Option 2: send LS to RAN1 to ask for clarification in this meeting

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| --- | --- | --- |
| Company | Option1/option2 | Comments |
| Huawei, HiSilicon | Option 1 | As we expect to have a clearer view after RAN1 finish the basic mechanisms of option1 and option2, we see no hurry to send LS in this meeting. |
| OPPO | Option 1 |  |
| Vivo |  | For safer, the finer granularity of RRC signalling is better, we also would like to send LS to RAN4 to ask their understanding. If RAN4 goes to same value for two cases we can reduce some UE capability report signalling. |
| Nokia, Nokia Shanghai Bell | Option 1 | This is already being discussed so there's no need for extra LSs. |
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## 3.4 RRC configuration

In Rel-16, RRC configuration parameters for UL Tx switching were introduced, e.g. period location and switching option (for UL CA case). From RAN4 agreed CR, RRC configuration is also needed for Rel-17 switching scenarios. In R2-2105623, it is proposed to introduce new RRC fields to configure the UL Tx switching for the 3 new Rel-17 scenarios, while R2-2106163 proposed to wait for more RAN1 progress. Considering RAN1 is still discussing what is the UE behaviour if UE supports both 1T-2T and 2T-2T switching, and whether/how network to indicate explicitly the UE to work in one scenario, it makes sense to wait for more RAN1 input before deciding RRC configuration design in RAN2.

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| R2-2106163 | Proposal 4: On how to design RRC configuration, RAN2 to wait for more RAN1 progress. |
| R2-2105623 | Proposal In R17 uplinkTxSwitching Option, uplinkTxSwitchingPeriod Location and uplinkTxSwitchingCarrier types are also needed. The uplink Tx Switching Carrier types can be extended to three carriers.  Proposal One of Three configuration types below can be added per CC with uplinkTxSwitchingPeriod Location and uplinkTxSwitchingCarrier types:  Type1: R17 1TX-2TX switching (Three UL carriers) configuration  Type2: R17 2TX-2TX switching (two UL carriers) configuration  Type3: R17 2TX-2TX switching (Three UL carriers) configuration |

**Q5: do companies agree to wait for more RAN1 progress on network configuration for Rel-17 UL Tx switching in UL CA case?**

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| Company | Agree (Yes/No) | Comments |
| Huawei, HiSilicon | Yes | It would be safer to wait for RAN1 progress a little bit longer before we capture RRC configuration now. |
| OPPO | Yes |  |
| Vivo |  | We are not sure if R16 TX switching is fall back case for below type 1 or type2. For safe, three new types is better for RRC configuration. However we are ok to wait.  Type1: R17 1TX-2TX switching (Three UL carriers) configuration  Type2: R17 2TX-2TX switching (two UL carriers) configuration  Type3: R17 2TX-2TX switching (Three UL carriers) configuration |
| Nokia, Nokia Shanghai Bell | Yes | Let's wait until we rush to design to avoid unnecessary work. |
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## 3.5 Any others issues

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| Company | Comments |
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# 3. Conclusion

TBD…

4. Contact information

|  |  |
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5. References

[R2-2104718](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_114-e\Docs\R2-2104718.zip) Reply LS on Rel-17 uplink Tx switching (R1-2104137; contact: China Telecom) RAN1 LS in Rel-17 NR\_RF\_FR1\_enh To:RAN4 Cc:RAN2

[R2-2104721](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_114-e\Docs\R2-2104721.zip) LS on Rel-17 Tx switching enhancements (R4-2103234; contact: China Telecom) RAN4 LS in Rel-17 NR\_RF\_FR1\_enh To:RAN1, RAN2

[R2-2105156](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_114-e\Docs\R2-2105156.zip) Consideration on Rel-17 UL Tx switching capability ZTE Corporation, Sanechips discussion Rel-17 NR\_RF\_FR1\_enh

[R2-2105157](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_114-e\Docs\R2-2105157.zip) Draft LS on Rel-17 UL Tx switching capability ZTE Corporation, Sanechips LS out Rel-17 NR\_RF\_FR1\_enh To:RAN4 Cc:RAN1

[R2-2106163](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_114-e\Docs\R2-2106163.zip) RAN2 impact to support R17 UL Tx switching enhancement Huawei, HiSilicon, China Telecom, CATT discussion Rel-17 NR\_RF\_FR1\_enh

[R2-2106164](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_114-e\Docs\R2-2106164.zip) Draft CR to TS38.331 to support Tx switching enhancements Huawei, HiSilicon, China Telecom, CATT draftCR Rel-17 38.331 16.4.1 NR\_RF\_FR1\_enh

[R2-2106165](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_114-e\Docs\R2-2106165.zip) Draft CR to TS38.306 to support Tx switching enhancements Huawei, HiSilicon, China Telecom, CATT draftCR Rel-17 38.306 16.4.0 NR\_RF\_FR1\_enh

[R2-2105982](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_114-e\Docs\R2-2105982.zip) UE capabilities for UL Tx switching enhancement Ericsson discussion

[R2-2105623](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_114-e\Docs\R2-2105623.zip) Rel-17 Tx switching enhancements vivo discussion Rel-17 NR\_RF\_FR1\_enh

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[R2-2105626](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_114-e\Docs\R2-2105626.zip) 38.331 CR on Rel-17 Tx switching enhancements vivo CR Rel-17 38.331 16.4.1 2634 - B NR\_RF\_FR1\_enh

[R2-2105627](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_114-e\Docs\R2-2105627.zip) 38.306 CR on Rel-17 Tx switching enhancements vivo CR Rel-17 38.306 16.4.0 0587 - B NR\_RF\_FR1\_enh