**3GPP TSG RAN WG1 #106bis-e R1-211xxxx**

**e-Meeting, October 11th – 19th, 2021**

**Agenda item:** 8.16.17

**Source:** Moderator (NTT DOCOMO, INC.)

**Title:** [draft] Summary on other UE feature related discussions

**Document for:** Discussion and Decision

# **Introduction**

This document summarizes contributions submitted to AI 8.16.17 including any other UE feature related discussions not directly relevant to 8.16.1 ~ 8.16.16, i.e., not captured in [1] or [2], and captures the following email discussion.

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| [107-e-R17-UE-features-Others-01] Email discussion UE features for other remaining issues – Shinya (DOCOMO)* 1st check point: November 15
* Final check point: November 19
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In this round of the discussion, companies are requested to provide comments on the proposals and questions tagged FL1.

# **UE features for UL Tx switching**

In [2], FG 37-x is captured as placeholder for potential RAN1 UE features for Rel-17 UL Tx switching.

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| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (Sidelink WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
|  37. [NR\_RF\_FR1\_enh] | 37-x |  |  |  |  |  |  |  |  |  |  |  |  |

Following feedbacks are provided in contributions for the RAN1#107-e meeting.

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| [3] | Huawei, HiSilicon | Based on RAN1 discussions on Rel-17 Tx switching, Rel-16 UE behaviors are fully reused to Rel-17. For UL CA Option 1, the mechanism of Rel-16 uplink switching specified in S6.1.6.2 of TS 38.214 is reused, with the additional clarification that a switching between two carriers also covers the case of 2-port transmission to 2-port transmission in addition to the existing cases of 2-port to 1-port and 1-port to 2-port transmissions [2], as shown by the following agreement.

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| **Agreements:*** For a UE configured with UL CA Option 1 and with 2Tx-2Tx UL Tx switching between two uplink carriers, the mechanism of uplink switching specified in S6.1.6.2 of TS 38.214 is reused with the following add-on.
* When the UE is to transmit a 2-port transmission on one uplink carrier and if the preceding uplink transmission is a 2-port transmission on another uplink carrier, then the UE is not expected to transmit for the duration of NTx1-Tx2 on any of the two carriers.
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| 1. 6.1.6.2 Uplink switching for carrier aggregation

For a UE indicating a capability for uplink switching with *BandCombination-UplinkTxSwitch* for a band combination, and if it is for that band combination configured with uplink carrier aggregation:- If the UE is configured with uplink switching with parameter *uplinkTxSwitching*, when the UE is to transmit in the uplink based on DCI(s) received before $T\_{0}-T\_{offset}$or based on a higher layer configuration(s):- When the UE is to transmit a 2-port transmission on one uplink carrier and if the preceding uplink transmission is a 1-port transmission on another uplink carrier, then the UE is not expected to transmit for the duration of $N\_{Tx1-Tx2}$ on any of the two carriers.- When the UE is to transmit a 1-port transmission on one uplink carrier and if the preceding uplink transmission is a 2-port transmission on another uplink carrier, then the UE is not expected to transmit for the duration of $N\_{Tx1-Tx2}$ on any of the two carriers. - For the UE configured with *uplinkTxSwitchingOption* set to 'switchedUL', when the UE is to transmit a 1-port transmission on one uplink carrier and if the preceding uplink transmission was a 1-port transmission on another uplink carrier, then the UE is not expected to transmit for the duration of $N\_{Tx1-Tx2}$ on any of the two carriers.- For the UE configured with *uplinkTxSwitchingOption* set to 'dualUL', when the UE is to transmit a 2-port transmission on one uplink carrier and if the preceding uplink transmission was a 1-port transmission on the same uplink carrier and the UE is under the operation state in which 2-port transmission cannot be supported in the same uplink carrier, then the UE is not expected to transmit for the duration of $N\_{Tx1-Tx2}$ on any of the two carriers.- For the UE configured with *uplinkTxSwitchingOption* set to 'dualUL', when the UE is to transmit a 1-port transmission on one uplink carrier and if the preceding uplink transmission was a 1-port transmission on another uplink carrier and the UE is under the operation state in which 2-port transmission can be supported on the same uplink carrier, then the UE is not expected to transmit for the duration of $N\_{Tx1-Tx2}$ on any of the two carriers.- The UE is not expected to be scheduled or configured with uplink transmissions that result in simultaneous transmission on two antenna ports on one uplink carrier, and any transmission on another uplink carrier.- In all other cases the UE is expected to transmit normally all uplink transmissions without interruptions. |

Compared with the existing UE behaviors as highlighted above, the new add-on in the agreement is obviously a simple clarification for UL-CA Option 1, which causes no unrealistic UE implementation issue. Therefore, we don’t see a need to have new UE capability for UL-CA Option 1.For UL CA Option 2, based on the Rel-17 agreement [2] and Rel-16 agreement [3], the only new UE behavior for the additional switching state is a simple clarification on the state ambiguity issue [4]. It does not cause any unrealistic UE implementation, as shown by the following agreements.Rel-17 [2][4]:

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| **Agreements:*** For inter-band UL CA, if 2Tx-2Tx UL Tx switching between two uplink carriers is configured:
* For option 2 of mapping between UL transmission ports and Tx chain
	+ The switching period is only applicable in the following cases:
		- If the current state of Tx chains is 1Tx on carrier 1 and 1Tx on carrier 2, the next UL transmission has a 2-port transmission on either carrier 1 or carrier 2.
		- If the current state of Tx chains is 0Tx on carrier 1 and 2Tx on carrier 2, the next UL transmission has a 1-port or 2-port transmission on carrier 1.
		- If the current state of Tx chains is 2Tx on carrier 1 and 0Tx on carrier 2, the next UL transmission has a 1-port or 2-port transmission on carrier 2.
	+ For other cases, the state of Tx chains of last UL transmission is assumed.
* Note: For SUL, UL CA option 1 and UL CA option 2, in RAN1 understanding, no spec change to power configuration and power control.
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| **Agreement:*** For UL-CA Option2, if UL Tx switching is triggered for 1-port transmission on a carrier and the state of Tx chains after the UL Tx switching is not unique, introduce a new RRC parameter to configure between 1) and 2)
	+ 1) The state of Tx chains supporting 2Tx transmission on the carrier is assumed.
	+ 2) 1Tx on carrier 1 and 1Tx on carrier 2 is assumed.
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Rel-16 [3]:

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| **Agreements:*** For inter-band UL CA, if uplink Tx switching is configured:
	+ ­For option 1 of mapping between UL transmission ports and Tx chain, the switching period is only applicable when the UL transmissions are switched between 1Tx carrier 1 and 2Tx carrier 2.
		- Note: 2Tx carrier 2 refers to an UL carrier capable of 2 Tx chains and both 1-port and 2-port UL transmissions.
	+ For option 2 of mapping between UL transmission ports and Tx chain
		- The switching period is only applicable in the following cases:
			* If the current state of Tx chains is 1 Tx on carrier 1 and 1Tx on carrier 2, the next UL transmission has a 2-port transmission on carrier 2.
			* If the current state of Tx chains is 0 Tx on carrier 1 and 2Tx on carrier 2, the next UL transmission has a 1-port transmission on carrier 1.
		- For other cases, the state of Tx chains of last UL transmission is assumed.
		- Note: No spec change to power configuration and power control.
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Therefore, for UL-CA Option 2, the only difference of UE behavior is also very small, which obviously cause no unrealistic implementation issue. We don't see a need to have new UE capability for UL-CA Option 2. There is existing FG 22-1 to indicate Option 1/Option 2 and it is per BC capability since Rel-16, as shown below.

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| Features | Index | Feature group | Components |
| 22. NR Others | 22-1 | Indicating supported option for UL Tx switching for inter-band UL CA | Indicating supported option for UL Tx switching for inter-band UL CACandidate values set is {option1, option2, both option 1 and option 2} |

Last meeting, new UE capability FG 37-1 is proposed as “Indicating supported option for UL Tx switching for 2Tx-2Tx inter-band UL CA” [1]:

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| 37. [NR\_RF\_FR1\_enh] | 37-1 | Indicating supported option for UL Tx switching for 2Tx-2Tx inter-band UL CA | Indicating supported option for 2Tx-2Tx UL Tx switching for inter-band UL CA* Candidate values set is {option1, option2, both option 1 and option 2}
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However, the FG37-1 overlaps with FG 22-1 and even does not take it as a prerequisite, which seems equivalently changing the existing FG 22-1 from per BC to per feature set, and thus causes unnecessary troubles for gNBs during network operation. The motivation for FG 37-1 seemed to grant a UE the flexibility to report Option1 only (or Option2 only) for 2Tx-2Tx even the UE has reported a support of {both Option 1 and Option 2} for 1Tx-2Tx. However, Rel-17 UL CA Option1 is exact the same as Rel-16 UL CA Option1, which both triggers UL Tx switching only when UL carrier is switched. Therefore, such motivation is not justified. The new FG37-1 is unnecessary. ***Observation:*** *Since Rel-16 UE behaviors of UL Tx switching is reused with small add-ons for Rel-17, the existing FG 22-1 is sufficient for Rel-17 UL Tx switching while new UE capability FG37-1 is unnecessary.*  |
| [4] | ZTE | In Rel-16, we have the following per-BC UE feature to supported option for UL Tx switching for inter-band UL CA.

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| Features | Index | Feature group | Components |
| 22. NR Others | 22-1 | Indicating supported option for UL Tx switching for inter-band UL CA | Indicating supported option for UL Tx switching for inter-band UL CA* Candidate values set is {option1, option2, both option 1 and option 2}
 |

Similarly, Rel-17 also specifies two different options for UL Tx switching for inter-band UL CA. From our perspective, it is not appropriate to always require UE to support the same option for Rel-16 UL Tx switching and Rel-17 UL Tx switching for iner-band UL CA. For example, UE may support “both Option1 and Option2” for Rel-16 1Tx-2Tx UL Tx switching, but it may only support “Option1” for Rel-17 UL Tx switching, Rel-17 UL Tx switching is enhanced from two perspectives, 1) from 1Tx-2Tx to 2Tx-2Tx switching; 2) from 2-carrier case to 3-carrier case switching. It may be ok to support the same option for 2-carrier case and 3-carrier case. But different options should be allowed for 1Tx-2Tx switching and 2Tx-2Tx switching. In RAN1#106b-e discussion, companies discussed the necessity of whether such a UE capability is needed. From our perspective, the UE capability is needed for the following reasons.1. Regarding the UE implementation complexity, Rel-16 UE only needs to support switching between two cases and only one Tx antenna is capable of switching between these two carriers. While Rel-17 UE needs to support switching between three cases and two Tx antennas are capable of switching between these two carriers. It is clear that there is additional UE implementation complexity for Rel-17 UL Tx switching on top of Rel-16.2. Regarding the relationship between FG22-1, our understanding is the following.* If UE supports Option1 for FG 37-1, the UE also needs to at least support Option1 for FG 22-1, UE may also support Option2 for FG22-1;
* If UE supports Option2 for FG 37-1, the UE also needs to at least support Option2 for FG 22-1, UE may also support Option1 for FG22-1;
* If UE supports both Option1 and Option2 for FG 37-1, the UE also needs to support both Option1 and Option2 for FG 22-1;

Thus, we propose the following proposal, which is also in line with what been discussed in RAN1#106b-e meeting.***Proposal 1****: Introduce the following UE feature for Rel-17 2Tx-2Tx UL Tx switching for inter-band UL CA.*

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| **Features** | **Index** | **Feature group** | **Components** | **Prerequisite feature groups** | **Need for the gNB to know if the feature is supported** | **Applicable to the capability signalling exchange between UEs (Sidelink WI only)”.** | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | **Need of FDD/TDD differentiation** | **Need of FR1/FR2 differentiation** | **Capability interpretation for mixture of FDD/TDD and/or FR1/FR2** | **Note** | **Mandatory/Optional** |
|  37. [NR\_RF\_FR1\_enh] | 37-1 | Indicating supported option for UL Tx switching for 2Tx-2Tx inter-band UL CA | Indicating supported option for 2Tx-2Tx UL Tx switching for inter-band UL CA* Candidate values set is {option1, option2, both option 1 and option 2}
 | FFS | Yes | N/A |  | Per BC | N/A | N/A | N/A |  | FFS details |

Note:* If UE supports Option1 for FG 37-1, the UE also needs to at least support Option1 for FG 22-1, UE may also support Option2 for FG22-1;
* If UE supports Option2 for FG 37-1, the UE also needs to at least support Option2 for FG 22-1, UE may also support Option1 for FG22-1;
* If UE supports both Option1 and Option2 for FG 37-1, the UE also needs to support both Option1 and Option2 for FG 22-1;
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| [5] | Nokia, Nokia Shanghai Bell | Define the FG for support of UL TX switching as:

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| 37. [NR\_RF\_FR1\_enh] | 37-1 | Indicating supported option for UL Tx switching for 2Tx-2Tx inter-band UL CA | Indicating support for 2Tx-2Tx UL Tx switching for inter-band UL CA | 22-1 | Yes | N/A |  | Per BC | N/A | N/A (FR1 only) | N/A | The UE supports the same options as signalled by FG 22-1. | FFS details |

**Proposal: Consider the observations and modifications proposed above for the next version of the corresponding RAN1 UE features list.** |
| [6] | Qualcomm | In RAN1 #106-emeeting, RAN2 made the following agreement [2].

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| Based on the following RAN2 agreements made in RAN2 #115 meeting, the R16 UE capability reporting should be extended to cover R17 scenarios.* No need to introduce Rel-17 UE capability of DL interruption for 2Tx-2Tx switching. The Rel-16 UE capability of DL interruption for 1Tx-2Tx switching applies to 2Tx-2Tx switching as well.
* To introduce Rel-17 per-band pair UE capability to indicate a different switching time for 2Tx-2Tx switching for a given BC (Option 1).
* The Rel-16 filter *uplinkTxSwitchRequest-r16* can be reused to request Rel-17 UL Tx switching UE capability.
* For R17 1Tx-2Tx/2Tx-2Tx switching between 1 carrier on band A and 2 contiguous aggregated carriers on band B for SUL and UL CA, RAN2 takes the following way-forward as RAN2 understanding.

Way-forward: the UE should report corresponding CA bandwidth class and UL MIMO layers in the UL featureSetPerCCs for 2 continuous CCs on band B in the legacy way. No new UE capability is needed specific to the case with 2CCs on band B. * On band B, the fallback capability from 2 CCs to 1 CC can be supported in the legacy way.
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Based on the agreement, we made following observation and share our initial considerations.

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| Capability name |  | R16 | Views on R17  |
| *ULTxSwitchingBandPair* | *bandIndexUL1, bandIndexUL2*  | Y | Agreed |
| *uplinkTxSwitchingPeriod* | Y | Agreed  |
| *uplinkTxSwitching-DL-Interruption* | Y | No need  |
| *supportedBandCombinationList-UplinkTxSwitch* |  | Y | Agreed  |
| *uplinkTxSwitching-OptionSupport* | Option 1 or 2 | Y | Need a new capability  |
| *uplinkTxSwitching-PowerBoosting* |  | Y | No need |
| *supportedBandCombinationList-UplinkTxSwitch* |  | Y | Agreed |

In RAN1 #106b-emeeting, FL made the following proposal based on the discussion. We support the FL’s following proposal [3].

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| **High priority proposal 2-1:*** **FG 37-1 is added as “Indicating supported option for UL Tx switching for 2Tx-2Tx inter-band UL CA” as follows**

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|  37. [NR\_RF\_FR1\_enh] | 37-1 | Indicating supported option for UL Tx switching for 2Tx-2Tx inter-band UL CA | Indicating supported option for 2Tx-2Tx UL Tx switching for inter-band UL CA* Candidate values set is {option1, option2, both option 1 and option 2}
 | FFS | Yes | N/A |  | Per BC | N/A | N/A (FR1 only) | N/A | If UE supports Option1 for FG 37-1, the UE also needs to support Option1 for FG 22-1;If UE supports Option2 for FG 37-1, the UE also needs to support Option2 for FG 22-1;If UE supports both Option1 and Option2 for FG 37-1, the UE also needs to support both Option1 and Option2 for FG 22-1; | FFS details |

Note that any contents highlighted in yellow mean FFS and to be discussed further. |

The only negative comment is on “*what exact UE implementation issue has been identified given the Rel-17 UE behaviour for 2Tx-2Tx is the same as Rel-16 one except for maybe the ambiguous state issue whose solution is only a baseband solution?*” and “*For Option 2 with the additional switching state, the only difference is a simple clarification on the state ambiguity issue. It does not cause any unrealistic UE implementation.*” Rel-17 UL Tx switching mainly has two sub-features – a new switching case (Case 3) and intra-band switching (2 carrier on band B). Some key issues requires ASN.1 impact including * Switching between the new Case (Case 3) and Case 1 & 2
* A new RRC IE to indicate the prioritized target case between Case 1 and 2Tx on the other band/carrier.
* One new switching time – 2Tx-2Tx and potential switch between the 2 switch modes (1Tx-2Tx & 2Tx-2Tx)

Given the above new UE & network behaviors would require changes of physical and upper layer specs, we support FL’s proposal on introduce the above new UE capability.**Proposal: Support FL’s proposal to introduce a new UE capability to indicate supported option for 2Tx-2Tx UL Tx switching for inter-band UL CA** |

## **Discussion**

**[FL1] Proposal 2-1:**

* **FG 37-1 is added as “Indicating supported option for UL Tx switching for 2Tx-2Tx inter-band UL CA” as follows**

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|  37. NR\_RF\_FR1\_enh | 37-1 | Indicating supported option for UL Tx switching for 2Tx-2Tx inter-band UL CA | Indicating supported option for 2Tx-2Tx UL Tx switching for inter-band UL CA* Candidate values set is {option1, option2, both option 1 and option 2}
 | FFS | Yes | N/A |  | Per BC | N/A | N/A (FR1 only) | N/A | If UE supports Option1 for FG 37-1, the UE also needs to support Option1 for FG 22-1;If UE supports Option2 for FG 37-1, the UE also needs to support Option2 for FG 22-1;If UE supports both Option1 and Option2 for FG 37-1, the UE also needs to support both Option1 and Option2 for FG 22-1; | FFS details |

Note that any contents highlighted in yellow mean FFS and to be discussed further.

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| Company | Comment |
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# **Conclusions**

TBD

# **References**

[1] R1-2110587 Updated RAN1 UE features list for Rel-17 NR after RAN1 #106bis-e Moderators (AT&T, NTT DOCOMO, INC.)

[2] R1-2110588 Updated RAN1 UE features list for Rel-17 LTE after RAN1 #106bis-e Moderators (AT&T, NTT DOCOMO, INC.)

[3] R1-2110800 Rel-17 UE features for UL Tx switching Huawei, HiSilicon

[4] R1-2110931 Discussion on Rel-17 UE features for UL Tx switching ZTE

[5] R1-2111167 On Remaining Rel-17 UE features Nokia, Nokia Shanghai Bell

[6] R1-2112262 UE features for Rel-17 UL Tx switching Qualcomm Incorporated