**3GPP TSG RAN WG1 #108-e R1-22xxxxx**

**e-Meeting, February 21st – March 3rd, 2022**

**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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| [108-e-R17-UE-features-Others-01] Email discussion on other Rel-17 UE feature issues – Shinya (DOCOMO)* 1st check point: February 25
* Final check point: March 3
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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#108-e meeting.

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| [3] | 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}
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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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| 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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| [4] | OPPO | For R17 UL Tx switching, one remaining issue is whether or not switching option can be reported differently for 1T-2T switching mode and 2T-2T switching mode [3]. RAN2 is waiting for RAN1’s conclusion on the issue [4]:

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| * Regarding whether switching option can be reported differently for 1T2T and 2T2T, RAN2 waits for RAN1 conclusion.
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For R16 Tx switching, the corresponding UE capability signaling is as below

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| uplinkTxSwitching-OptionSupport-r16 ENUMERATED {switchedUL, dualUL, both} OPTIONAL, |

For a R16 UE supporting UL Tx switching, it is possible to support both single UL and dual UL modes in order to support all possible practical deployments for various operators. However, with the evolution of commercial 5G network, it would be clearer which mode(s) will be widely used for R17 network. Thus, there may be more information for UE vendors and chipset vendors to decide which modes should be supported by a R17 UE:* If both modes will be widely used in R17 network, a R17 UE will support both modes
* If only one mode is widely used in R17 network, a R17 UE is likely to only support that mode.

From the perspective of UE implementation, introducing a separate UE capability regarding the switching mode for R17 UL Tx switching will offer more flexibility with the potential reduction of workload for implementation and testing. Proposal 1: For R17 UL Tx switching, introduce a separate UE capability to reporting the supported switching mode(s) and the candidate values are as below* + switchedUL, dualUL, both
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| [5] | Nokia, NSB | 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 |

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| [6] | China Telecom | In our understanding, it is not necessary to introduce a new FG for Rel-17 Tx switching. If a UE can support 2Tx-2Tx switching and Tx switching between 2 UL bands for Rel-17 Tx switching, it can easily support 1Tx-2Tx switching between 2 UL carriers for Rel-16 Tx switching for the same option. UE can reuse FG 22-1 defined in Rel-16 to report the same option for Rel-17 Tx switching. If it is indeed necessary to introduce a new FG for Rel-17 Tx switching. The only motivation of introducing of a new FG for Rel-17 Tx switching is that UE may support both Option 1 and Option 2 for Rel-16 Tx switching while it may only support either Option 1 or Option 2 for Rel-17 Tx switching. However, this may cause fragmentation of the commercial network. For instance, if the network supports Rel-16 Tx switching with UL CA option 1, when the network is upgraded to support Rel-17 Tx switching, it’s probably that the network stills support UL CA option 1 for Rel-17 Tx switching to save investment. In this case, if a UE reports supporting both UL CA option 1 and option 2 for Rel-16 Tx switching while the UE reports only supporting option 2 for Rel-17 Tx switching, the network has to fall back to Rel-16 Tx switching. As an operator, we need to protect our investment. Then why do we need to upgrade the network to support Rel-17 Tx switching? The motivation for us to upgrade the network to support Rel-17 Tx switching is on condition that the UE at least support the same option for Rel-17 as Rel-16. We have following proposal:**Proposal: Adopt one of the following alternatives for UE feature for Rel-17 Tx switching.*** **Alt 1: No new FG is introduced for Rel-17 Tx switching**
* **Alt 2: A new FG 37-1 is introduced for Rel-17 Tx switching**
	+ **If a UE supports Option 1 for FG 22-1, the UE also needs to support Option 1 for FG 37-1;**
	+ **If a UE supports Option 2 for FG 22-1, the UE also needs to support Option 2 for FG 37-1;**
	+ **If a UE supports both Option 1 and Option 2 for FG 22-1, the UE also needs to support both Option 1 and Option 2 for FG 37-1.**
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| [7] | DOCOMO | * Whether to introduce FG 37-1 as “Indicating supported option for UL Tx switching for 2Tx-2Tx inter-band UL CA”
	+ The relationship between proposed new FG 37-1 and FG 22-1 for Rel-16 UL Tx switching has been discussed [2]. It was argued by proponents of new FG 37-1 that UE supporting both option 1 and option 2 for FG 22-1 (Rel-16 UL Tx switching between case 1 and 2) may not support one of the options for FG 37-1 (Rel-17 UL Tx switching among case 1, 2 and 3), and hence having FG 37-1 is beneficial. However, some other companies commented that UE supporting Rel-16 UL Tx switching option 1 (or option 2) and 2Tx-2Tx should also support Rel-17 UL Tx switching option 1 (or option 2), and hence the indication of supported option in FG 22-1 can be reused for Rel-17 UL Tx switching.
	+ Since Rel-17 UL Tx switching requires additional implementation compared with Rel-16 UL Tx switching, at least separate capabilities on the support of Rel-17 UL Tx switching and the support of Rel-16 UL Tx switching are necessary, and it may be covered by capabilities agreed in RAN2. So, here we can focus on whether supporting the same option as in Rel-16 is mandatory for Rel-17 UL Tx switching or not. Although we don’t have a strong view on it, we are fine to not mandate it as there are several companies supporting to have flexibility on the support of different options between Rel-16 (1Tx-2Tx) and Rel-17 (2Tx-2Tx) UL Tx switching. As Rel-17 is more advanced feature, supporting the same option as in Rel-17 can be mandatory for Rel-16 UL Tx switching.
	+ Therefore, we think that FG 37-1 can be defined as optional with capability signalling to report the supported option(s) for Rel-17 2Tx-2Tx UL Tx switching, where FG 22-1 is prerequisite FG for the FG 37-1 and the type is per BC (FR1 only). The UE’s supported option(s) for Rel-17 2Tx-2Tx UL Tx switching in FG 37-1 should also be supported for FG 22-1.

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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}
 | 22-1 | 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; | Optional with capability signalling |

**Proposal 1:** **The new FG 37-1 is defined for “Indicating supported option for UL Tx switching for 2Tx-2Tx inter-band UL CA”.*** **Candidate values set is {option1, option2, both option1 and option2}**
* **The prerequisite FG is FG22-1**
* **The type of the FG is Per BC (FR1 only)**
* **The FG is optional with capability signalling**
* **The UE’s supported option(s) for Rel-17 2Tx-2Tx UL Tx switching in FG 37-1 should also be supported for FG 22-1**
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| [10] | Qualcomm | For Rel-17 UL Tx switching, 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 |

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 as follows. * 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 feel it would be good to define an new UE capability for Rel-17 inter-band CA UL Tx switching..**Proposal: Introduce a new UE capability to indicate supported option for 2Tx-2Tx UL Tx switching for inter-band UL CA** |
| [11] | Huawei, HiSilicon | Based on RAN1 discussions on Rel-17 Tx switching, Rel-16 UE behaviors are fully reused to Rel-17. For example, 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} |

In RAN1#107-e, new UE capability FG 37-1 is proposed as “Indicating supported option for UL Tx switching for 2Tx-2Tx inter-band UL CA” [1]. The reasoning seemed that Rel-17 UL Tx switching is new so that new UE capability is needed.

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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 |

However, in RAN2#116bis-e, the following agreed CR[5] has shown that the “*uplinkTxSwitchingPeriod2T2T*” is used to indicated whether 2Tx-2Tx switching is supported by UE supporting 1Tx-2Tx switching. There is no need to add FG 37-1 to indicate whether UE support R17 UL Tx switching.

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| ULTxSwitchingBandPair-v17xx ::= SEQUENCE {uplinkTxSwitchingPeriod2T2T-r17 ENUMERATED {n35us, n140us, n210us} OPTIONAL} |

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| ***supportedBandPairListNR-r16, supportedBandPairListNR-v17xx***Indicates a list of band pair supporting UL Tx switching as defined in TS 38.101-1 [15] for a given band combination. A UE supporting 2Tx-2Tx switching should include both of *supportedBandPairListNR-r16* and *supportedBandPairListNR-v17xx*. And the UE shall include the same number of entries listed in the same order as in *supportedBandPairListNR-r16.**If the UE does not support 2Tx-2Tx switching for a given band pair, the field of uplinkTxSwitchingPeriod2T2T in the corresponding entry is absent.* |

Besides, the proposed FG37-1 overlaps with FG 22-1 and even does not take it as a prerequisite, which seems equivalent to changing the existing FG 22-1 from per BC to per feature set, and thus causes unnecessary troubles for gNBs during network operation.Another motivation for FG 37-1 seemed to grant a UE the flexibility to report Option 1 only (or Option 2 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. It’s unreasonable that a UE capable of Rel-16 Option 1 and 2Tx-2Tx cannot support Rel-17 Option 1 by the new capability FG 37-1. This would cause unnecessary troubles for gNB only capable of Rel-16 Option 1 and Rel-17 Option 1. Therefore, the new FG37-1 is not justified and 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.* |

## **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}
 | 22-1 | 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; | Optional with capability signalling |

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| Company | Comment |
| Moderator | Summary of companies view* Support: ZTE, OPPO, Nokia/NSB, DOCOMO, QC
	+ *Rel-17 UE needs to support switching between three cases and two Tx antennas are capable of switching between these two carriers*
	+ *more flexibility with the potential reduction of workload for implementation and testing*
	+ *The UE’s supported option(s) for Rel-17 2Tx-2Tx UL Tx switching in FG 37-1 should also be supported for FG 22-1*
* Not support: CT, HW/HiSi
	+ *cause fragmentation of the commercial network*
	+ *no unrealistic UE implementation issue*
	+ *Based on RAN2 agreement*
	+ *The UE’s supported option(s) for Rel-16 1Tx-2Tx UL Tx switching in FG22-1 should also be supported for Rel-17 2Tx-2Tx UL Tx switching*

Similar to the last RAN1 meeting, companies still have different view on whether to introduce additional FG for indicating supported option for UL Tx switching for 2Tx-2Tx inter-band UL CA.The main discussion point would be whether to allow flexibility for the supported option for UL Tx switching for 2Tx-2Tx inter-band UL CA, i.e., whether the same option(s) should be supported for Rel-16 and Rel-17.**@Companies who support to add FG 37-1:** Please provide view why such flexibility for the supported option is necessary for Rel-17.**@Companies who don’t support to add FG 37-1**: Please provide view why such flexibility for the supported option is NOT necessary for Rel-17. |
| NTT DOCOMO | For a certain band combination, UE supporting Rel-17 2Tx-2Tx UL Tx switching can/should also indicate the support of Rel-16 1Tx-2Tx UL Tx switching as gNB may not support Rel-17 UL Tx switching but may support Rel-16 UL Tx switching. The UE supporting Rel-17 2Tx-2Tx UL Tx switching may indicate the support of option 1 for Rel-17 2Tx-2Tx UL Tx switching, while the UE may indicate the support of both option 1 and option 2 for Rel-16 1Tx-2Tx UL Tx switching. The option 2 for Rel-17 2Tx-2Tx UL Tx switching requires to support the switching among three cases (case 1{1P+0P, 1P+1P, 0P+1P}, case 2{0P+2P, 0P+1P}, case 3{2P+0P, 1P+0P}), while the option 2 for Rel-16 1Tx-2Tx UL Tx switching requires to support the switching between two cases (case 1{1P+0P, 1P+1P, 0P+1P}, case 2{0P+2P, 0P+1P}) and the option 1 for Rel-17 2Tx-2Tx UL Tx switching also requires to support the switching between two cases (case 2{0P+2P, 0P+1P}, case 3{2P+0P, 1P+0P}). Since the support of switching among three cases would require additional implementation and test, we think introducing FG37-1 to allow UE reporting different options between Rel-16 1Tx-2Tx switching and Rel-17 2Tx-2Tx switching would be beneficial. Otherwise, if FG37-1 is not introduced and Rel-16 FG is reused to indicate the supported option(s) for both Rel-16 1Tx-2Tx switching and Rel-17 2Tx-2Tx switching, UE may under-report its capability (e.g., support only option 1) even if the UE can support and can be successfully tested for option 2 for Rel-16 1Tx-2Tx switching. |
| Qualcomm | We don’t understand what “cause fragmentation of commercial network” is. This seems to be a new concept, at least to us. Do the companies not supporting the proposal mean that all networks would somehow end up supporting only one of the options if the proposal is not adopted? Or do they mean that somehow either Rel-16 or Rel-17 would be cancelled, so only UEs of one release will exist? We support to introduce a Rel-17 UE capability for following two reasons.1. The UE will use different antennas and/or different RF component configuration for the 1Tx-2Tx case compared to 2Tx-2Tx. Therefore, supporting Rel-16 Option 2 for the former may not imply supporting Rel-17 Option 2 for the latter. 2. Rel-17 specifies new UE behaviours compared with Rel-16, which would require additional IoDT before commercial launch. Without this new UE capability, or defining it by the CT proposed pre-requisite, there would be a risk because IoDT opportunity will not be available for all possible combination of supported capability candidate value settings at the same time.   |
| ZTE | Rel-16 UL Tx switching defined Option1 and Option2. Rel-17 also defines Option1 and Option2, the name of the two options happen to the same, it doesn’t mean the UE behaviour of Rel-16 Option1/2 and Rel-17 Option1/2 is the same. In fact, one can argue that UE behaviour for Rel-16 Option1 and Rel-17 Option1 may be similar. However, Rel-16 Option2 and Rel-17 Option2 are clearly different. Even the supported cases are different. Without this Rel-17 UE capability, UE has to support the same UE options for both Rel-16 and Rel-17, which is not reasonable from our perspective.Overall, we support to have this Rel-17 FG. This is not just for higher flexibility, it is a necessity from our understanding.  |
| OPPO | Support to add this feature group and the Yellow part should be removedFor a R16 UE supporting UL Tx switching, it is possible to support both single UL and dual UL modes in order to support all possible practical deployments for various operators. However, with the evolution of commercial 5G network, it would be clearer which mode(s) will be widely used for R17 network. Thus, there may be more information for UE vendors and chipset vendors to decide which modes should be supported by a R17 UE:* If both modes will be widely used in R17 network, a R17 UE will support both modes
* If only one mode is widely used in R17 network, a R17 UE is likely to only support that mode.

From the perspective of UE implementation, introducing a separate UE capability regarding the switching mode for R17 UL Tx switching will offer more flexibility with the potential reduction of workload for implementation and testing.  |

# **UE features for SRS carrier switching**

Following proposals are provided in contributions for the RAN1#108-e meeting.

|  |  |  |  |
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| [3] | ZTE | Priority rule issues of SRS carrier switching has been discussed in several meetings before RAN1#107-e (in agenda 7.1 Maintenance of Release 15 NR). It was common understanding that the prioritization rules are at least used between SRS transmission in target carrier *c1* and other UL signal(s) in a carrier *c2* where *c2* is any one carrier which is in the same band with switching from (or called source carrier) carrier *cs*. However, it is still unclear whether the prioritization rules can be used between SRS transmission in target carrier *c1* and another carrier *c3* where *c3* is from a different band with switching from (source carrier) carrier *cs* for inter-band CA case.In RAN1#107-e meeting, the issues on SRS carrier switching priority rules were discussed again and the following conclusion is made.

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| Conclusion in RAN1#107-eRegarding SRS carrier switching priority rules:* For Rel-16, it is concluded that no modification in specifications should be made to clarify the current UE behaviour or to introduce a new UE behaviour regarding SRS carrier switching priority rules.
* For releases later than Rel-16, it is concluded to consider introducing a new UE capability for indicating simultaneous transmission while switching, and/or clarify the UE behaviour in the case of intra-band CA.
	+ Note: If introduced, the new UE capability should always assume no simultaneous transmission while SRS carrier switching for the bands in the band combinations that are signalled to not support simultaneous transmission within *BandCombinationList-UplinkTxSwitch*.
 |

Because modification for Rel-16 may cause backward compatible issues for both gNB and UE implementation, most companies suggested introducing a new UE capability for the release later than Rel-16. As Rel-17 UE feature is under discussion, we propose to introduce the new UE FG in Rel-17 to clarify the issues for inter-band CA case as soon as possible. Specifically, the new Rel-17 UE FG should be reported per BandCombination to indicate if UL transmission in one band within a BandCombination impacts UL transmission in another band within the BandCombination. That is, within a BandCombination, if UL transmission in band *a* impacts UL transmission in band *b*, carriers in the band *a* and in the band *b* should be always applied in the SRS carrier switching priority rules together. If the switching from (source carrier) carrier *cs* in band *a* (or *b*), the uplink carriers in band *b* (or *a*) should also be used in the SRS carrier switching priority rules. Here is our suggestion,***Proposal 2:*** *Introduce a new Rel-17 UE FG to indicate if UL transmission in one band within a BandCombination impacts UL transmission in another band within the BandCombination for SRS carrier switching.*  |

## **Discussion**

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| Company | Comment |
| Moderator | As per RAN1 chair guidance, this issue will be discussed in [108-e-NR-CRs-04] |

# **UE features for cross PUCCH group CSI report**

Following proposals are provided in contributions for the RAN1#108-e meeting.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| [8] | Apple | In RAN1#107 meeting, for the discussion of RAN4 LS on cross PUCCH group CSI report in R1-2108704 [1], the following agreement was reached [2]

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| AgreementIn response to the LS from RAN4 on beam information of PUCCH Scell in PUCCH SCell activation procedure, the following RAN1 responses are agreed.Q1: Whether UE can report CSI (e.g. L1-RSRP) of the target being-activated PUCCH SCell belonging to secondary PUCCH group by configuring CSI report setting (e.g. CSI-ReportConfig) on any active serving cells belonging to primary PUCCH group**FL proposal 1-1-rev:** There is no restriction in the current RAN1 specification that would not allow UE to report CSI of a SCell belonging to secondary/primary PUCCH group by PUSCH or PUCCH of active serving cells belonging to primary/secondary PUCCH group. But there is no RAN1 consensus on whether all UEs supporting NR-CA with dual PUCCH-groups for the BC support such CSI report in Rel-15 and Rel-16. Support of such CSI report is indicated in Rel-17 with a new UE capability* potential CSI processing timeline relaxation for UEs reporting the new UE capability can be discussed.

Q2: Whether the above observation is correct, i.e. the identified four cases are not supported by the current RAN1 and RAN2 specification**FL proposal 2-1-rev:** RAN1 is not able to answer the question on whether the identified four cases are supported or not by current RAN1 specification.Q3: Whether the above identified cases can be supported by RAN1 and RAN2 spec updates within Rel-17 timeframe.**FL proposal 3-1-rev:** RAN1 is not able to answer the question. However, RAN1 expects that reporting CSI (e.g. L1-RSRP) of the target being-activated PUCCH SCell belonging to secondary PUCCH group by configuring CSI report setting (e.g. CSI-ReportConfig) on any active serving cells belonging to primary PUCCH group supports the identified four cases. |

Based on the agreement and the highlighted part, we need to define UE capability for the support of cross PUCCH group CSI report in Rel-17. There are at least two things we need to address * We need to separately consider fours type of CSI report supported currently in NR, including
	+ Periodic CSI report on PUCCH
	+ Semi-persistent CSI report on PUCCH
	+ Semi-persistent CSI report on PUSCH
	+ Aperiodic CSI report on PUSCH
* In a BC, even if UE indicates UE supports cross PUCCH group CSI report, it should not be assumed that UE can perform cross PUCCH group report between any two bands.

Based on the above consideration, we have the following proposed FG for the support of cross PUCCH group CSI report in Rel-17**Proposal 1: Introduce per BC UE capability reporting for the support of cross PUCCH group CSI report in Rel-17, with the following TP**

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| **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 (V2X 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 differe-ntiation** | **Need of FR1/FR2 differentiation** | **Capability interpretation for mixture of FDD/TDD and/or FR1/FR2** | **Note** | **Mandatory/Optional** |
| 39-1 | Cross PUCCH group CSI report | 1. Support of cross PUCCH group CSI report (the CSI measurement and the CSI report are performed in different PUCCH group) for the following CSI reports (1) periodic CSI report (P-CSI) on PUCCH (2) semi-persistent CSI report (SP-CSI) on PUCCH (1) semi-periodic CSI report (SP-CSI) on PUSCH (1) aperiodic CSI report (AP-CSI) on PUSCH
2. Supported band pair(s) for cross PUCCH group CSI report
 | 2-35 | Yes | N/A |  | Per BC | No | No |  | Component 1: candidate values with bitmap {P-CSI on PUCCH, SP-CSI on PUCCH, SP-CSI on PUSCH, AP-CSI on PUSCH}Component 2: A list of up to 16 band pairs.For each band pair, it contains {band in which CSI measurement is performed, band in which CSI report is performed}  | Optional with capability signaling |

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| [9] | MediaTek | In R1-2112858 “Reply LS on beam information of PUCCH SCell in PUCCH SCell activation procedure”, RAN1 replied a LS to RAN4 about the feasibility of cross-PUCCH-group CSI report on PUCCH:**Q1:** Whether UE can report CSI (e.g. L1-RSRP) of the target being-activated PUCCH SCell belonging to secondary PUCCH group by configuring CSI report setting (e.g. CSI-ReportConfig) on any active serving cells belonging to primary PUCCH group**Answer**: There is no restriction in the current RAN1 specification that would not allow UE to report CSI of a SCell belonging to secondary/primary PUCCH group by PUSCH or PUCCH of active serving cells belonging to primary/secondary PUCCH group. But there is no RAN1 consensus on whether all UEs supporting NR-CA with dual PUCCH-groups for the BC support such CSI report in Rel-15 and Rel-16. Support of such CSI report is indicated in Rel-17 with a new UE capability. Potential CSI processing timeline relaxation for UEs reporting the new UE capability can be discussed.It can be seen that RAN1 agrees to introduce a new UE capability in Rel-17 for cross-PUCCH-group CSI report on PUCCH. **Observation 1: In R1-2112858 “Reply LS on beam information of PUCCH SCell in PUCCH SCell activation procedure”, RAN1 agrees to introduce a new UE capability in Rel-17 for cross-PUCCH-group CSI report on PUCCH.**We hence have the following proposal:**Proposal 1: Introduce a new UE capability in Rel-17 for cross-PUCCH-group CSI report on PUCCH in the RAN1 UE feature table.**

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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 |
| 39. NR\_Cross\_PUCCH\_group\_CSI\_report | 39-1 | Cross-PUCCH-group CSI report on PUCCH | Support cross-PUCCH-group CSI report on PUCCH | 6-7 | Y |  | UE does not support cross-PUCCH-group CSI report on PUCCH | Per UE | N | N | N |  | Optional with capability signaling |

 |
| [12] | Huawei, HiSilicon | The new Rel-17 UE capability of supporting cross PUCCH group CSI report is introduced for PUCCH SCell activation, it should be conditional mandatory for the UEs supporting PUCCH SCell, otherwise new solution would need to be defined for the UE not supporting it but supporting PUCCH SCell. The capability is associated to UE baseband, it should be reported per-UE level. An initial view on the new Rel-17 UE feature can be found in the appendix.***Proposal 1:*** *An initial view on the new Rel-17 UE feature in the appendix should be discussed as a start point.*

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| Rel-17 Further RRM enhancement for NR and MR-DC | x-1 | CSI reporting cross PUCCH group | 1. Support reporting CSI of an active/being activated SCell belonging to secondary PUCCH group by PUSCH or PUCCH of active serving cells belonging to primary PUCCH group.
2. Support reporting CSI of an active/being activated SCell belonging to primary PUCCH group by PUSCH or PUCCH of active serving cells belonging to secondary PUCCH group.
 | [6-7] | Yes | N/A | Cross-PUCCH group CSI report is not supported | Per UE | No | No | N/A |  | Conditional mandatory if the UE supports two PUCCH groups |

* CSI processing timeline

Considering the UE CSI computation time, $Z\_{ref}$ and $Z\_{ref}^{'}$ are defined to determine whether UE shall provide a valid CSI report. $Z\_{ref}$ is the time (including TA) from the end of the last symbol of the PDCCH that triggers the CSI report to the start of the first symbol of the PUSCH that contains the CSI report and $Z\_{ref}^{'}$ is the time (including TA) from the end of the last symbol of the latest resource in the aperiodic CSI-RS resource used for channel measurement and interference measurement and the end of the last symbol of the aperiodic CSI-IM resource used for interference measurement to the start of the first symbol of the PUSCH including the CSI report as illustrated in the Figure 1Figure 1 CSI processing timelineIf cross PUCCH group CSI report is supported, the main difference is that the triggered aperiodic CSI-RS resources and PUSCH with CSI report are in different PUCCH groups compared with legacy CSI report, so only $Z\_{ref}^{'}$ is related to potential CSI processing timeline relaxation. However, processing time requirements for $Z\_{ref}^{'}$ in Table 5.4-1 and 5.4-2 in TS 38.214 [3] do not differentiate which serving cell the CSI-RS resource is received on, i.e. the requirements are the same for all serving cells, and it seems not impacted by PUCCH group either. Furthermore, no issues are identified from UE implementation perspective.***Proposal 2:*** *Rel-16 CSI processing timeline can be reused for UEs reporting the new UE capability of support cross-PUCCH group CSI report, no RAN1 spec impact is needed.* |

## **Discussion**

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| Company | Comment |
| Moderator | As per RAN1 chair guidance, this issue will be discussed in [108-e-AI5-LSs-05]. |

# **Conclusions**

TBD

# **References**

[1] R1-2112900 Updated RAN1 UE features list for Rel-17 LTE after RAN1 #107-e Moderators (AT&T, NTT DOCOMO, INC.)

[2] R1-2200780 Updated RAN1 UE features list for Rel-17 NR after RAN1 #107bis-e Moderators (AT&T, NTT DOCOMO, INC.)

[3] R1-2201181 Discussion on other Rel-17 UE features ZTE

[4] R1-2201231 Discussion on Rel-17 UE feature for Tx Switching enhancement OPPO

[5] R1-2201424 On Remaining Rel-17 UE features Nokia, Nokia Shanghai Bell

[6] R1-2201449 UE features for Rel-17 Tx switching China Telecom

[7] R1-2201513 Discussion on other UE feature related discussions NTT DOCOMO, INC.

[8] R1-2201803 Rel-17 UE features on cross PUCCH group CSI report Apple

[9] R1-2202055 On UE features for others MediaTek Inc.

[10] R1-2202181 UE features for Rel-17 UL Tx switching Qualcomm Incorporated

[11] R1-2202471 Rel-17 UE features for UL Tx switching Huawei, HiSilicon

[12] R1-2202429 Remaining issues on beam information of PUCCH SCell in PUCCH SCell activation procedure Huawei, HiSilicon