**3GPP TSG RAN WG1 #118 R1-2407435**

**Maastricht, NL, August 19th – 23rd, 2024**

Source: Moderator (NTT DOCOMO, INC.)

Title: Summary#4 of discussion on Multi-carrier UL Tx switching scheme

Agenda Item: 8.1

Document for: Discussion and Decision

1. Introduction

This contribution summarizes contributions submitted to AI 8.1 regarding multi-carrier UL Tx switching scheme and corresponding discussion at RAN1#118 meeting.

Any announcement regarding this summary is provided in following email thread.

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| [118-R18-Maintenance] To be used for sharing updates on online/offline schedule, details on what is to be discussed in online/offline sessions, tdoc number of the moderator summary for online session, etc – Chair |

1. References

[1] R1-2406993 Corrections on Rel-18 UL Tx switching with two configured bands Huawei, HiSilicon

[2] R1-2405609 Summary#2 of discussion on Multi-carrier UL Tx switching scheme Moderator (NTT DOCOMO, INC.)

[3] R1-2400007 LS on UL Tx Switching RAN2, Huawei

[4] R1-2401776 Reply LS on UL Tx switching RAN1, NTT DOCOMO, INC.

1. Discussion

## 3.1 Further discussion on RAN2 LS

At the RAN1#116 meeting, RAN1 received a LS from RAN2 in [3], and RAN1 sent a reply LS in [4] based on following RAN1 agreement. RAN1 needs further discussion on yellow highlighted case.

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| **Agreement**RAN1 replies to RAN2 LS in R1-2400007 as below.* RAN1 confirms that the first RAN2 agreement in the LS R1-2400007/R2-2313959 has no issue from RAN1 perspective, except for a case where Rel-18 UL Tx switching is configured with band combination {A, B} to a UE reporting support of UL Tx switching for band combination {A, B, C} /{A, B, C, D} and no UL-MIMO on band A nor band B. For the case, RAN1 continues to discuss it.

Final LS is in R1-2401776. |

In contributions, following proposals were provided.

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| [1]Huawei, HiSilicon | **Reason for change:**Capture in TS 38.214 the following RAN2 and RAN1 agreements of configuring two bands uplink switching by Rel-18 configuration signaling.

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| R1-2400007/R2-2313959:For Rel-18 UL Tx switching, RAN2 achieved the following agreements in RAN2 #124 meeting:* RAN2 confirms that Rel-18 signalling can configure 2 bands UL Tx switching for a band pair that the UE supports according to the Rel-18 band pair list UE capability, in which case the network and UE assume the capability reported for R18 UL Tx switching is used. RAN2 respectfully asks RAN4 and RAN1 to take this into account, and feedback to RAN2 in case there is any concern.
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| R1-2401776:RAN1 confirms that the first RAN2 agreement in the LS R1-2400007/R2-2313959 has no issue from RAN1 perspective, except for a case where Rel-18 UL Tx switching is configured with band combination {A, B} to a UE reporting support of UL Tx switching for band combination {A, B, C} /{A, B, C, D} and no UL-MIMO on band A nor band B. For the case, RAN1 continues to discuss it. |

**Summary of change:**Replace the phrase of “with 3 or 4 uplink bands” with “with 2, 3 or 4 uplink bands”**Consequence if not approved:**Incomplete specification on uplink Tx switching with two configured bands.

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| 6.1.6 Uplink switchingThe UE may omit uplink transmission during the uplink switching gap $N\_{Tx1-Tx2}$if the conditions defined in this clause are met and the UE is configured with *uplinkTxSwitching* or *uplinkTxSwitchingMoreBands*. The switching gap $N\_{Tx1-Tx2}$is indicated by UE capability *uplinkTxSwitchingPeriod2T2T* if *uplinkTxSwitching-2T-Mode* is configured, and *uplinkTxSwitchingPeriod* otherwise in clauses 6.1.6.1, 6.1.6.2.0, 6.1.6.3, and is determined based on higher layer parameter *switchingPeriodConfigForBandPair* in clause 6.1.6.2.2 for uplink switching configured with 2, 3 or 4 uplink bands if *UplinkTxSwitchingMoreBands* is configured: - If a UE indicated a capability for uplink switching with *BandCombination-UplinkTxSwitch* for a band combination, and if it is for that band combination- Configured with a MCG using E-UTRA radio access and with a SCG using NR radio access (EN-DC), or- Configured with uplink carrier aggregation, or- Configured in a serving cell with two uplink carriers with higher layer parameter *supplementaryUplink*. The conditions under which the switching gap may be present are defined for each of the cases in clauses 6.1.6.1, 6.1.6.2, and 6.1.6.3 respectively.< Unchanged parts are omitted >6.1.6.2.2 Uplink switching with 3 or 4 uplink bandsFor 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 with 2, 3 or 4 bands, the behaviour in subclause 6.1.6.2.0 applies when the two bands involved in the uplink switching belong to different uplink serving cells with the parameters *uplinkTxSwitching*, *uplinkTxSwitchingOption* and *uplinkTxSwitching-2T-Mode* beingreplaced by *UplinkTxSwitchingMoreBands, switchingOptionConfigForBandPair* and *switching2T-Mode,* respectively, and the behaviour in subclause 6.1.6.3 with the parameter *uplinkTxSwitching* being replaced by *UplinkTxSwitchingMoreBands* applies when the two bands involved in the uplink switching belong to one uplink serving cell, with the following exceptions:- If more than two bands are involved in the determination of one uplink switching and if on any two of the bands the UE is configured with *switchingOptionConfigForBandPair* set to 'dualUL',< Unchanged parts are omitted > |

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This issue was extensively discussed at RAN1#116bis and RAN1#117 meeting, but RAN1 could not achieve any consensus on whether/how to handle concerned scenario of 1T-1T switching with only 2 bands. The proponent has argued that the proposed TP is anyway necessary as RAN1 confirmed RAN2 agreement that Rel-18 signalling can configure 2 bands UL Tx switching for a band pair that the UE supports according to the Rel-18 band pair list UE capability. Since there is no contribution for the discussion on whether/how to handle concerned scenario of 1T-1T switching with only 2 bands at this meeting, the moderator assumes RAN1 can/should discuss the proposed TP to resolve remaining RAN1 specification impact for the RAN2 agreements of configuring two bands uplink switching by Rel-18 configuration signaling.

### **Proposed agreement 3.1**

* Agree on following TP

**Reason for change:**

Capture in TS 38.214 the RAN2 agreements of configuring two bands uplink switching by Rel-18 configuration signaling.

**Summary of change:**

Replace “3 or 4 uplink bands” by “2, 3 or 4 uplink bands” in section 6.1.6 and 6.1.6.2.2.

**Consequence if not approved:**

Rel-18 configuration signaling cannot be used for the case of configuring two bands uplink switching.

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| 6.1.6 Uplink switchingThe UE may omit uplink transmission during the uplink switching gap $N\_{Tx1-Tx2}$if the conditions defined in this clause are met and the UE is configured with *uplinkTxSwitching* or *uplinkTxSwitchingMoreBands*. The switching gap $N\_{Tx1-Tx2}$is indicated by UE capability *uplinkTxSwitchingPeriod2T2T* if *uplinkTxSwitching-2T-Mode* is configured, and *uplinkTxSwitchingPeriod* otherwise in clauses 6.1.6.1, 6.1.6.2.0, 6.1.6.3, and is determined based on higher layer parameter *switchingPeriodConfigForBandPair* in clause 6.1.6.2.2 for uplink switching configured with 2, 3 or 4 uplink bands if *UplinkTxSwitchingMoreBands* is configured: - If a UE indicated a capability for uplink switching with *BandCombination-UplinkTxSwitch* for a band combination, and if it is for that band combination- Configured with a MCG using E-UTRA radio access and with a SCG using NR radio access (EN-DC), or- Configured with uplink carrier aggregation, or- Configured in a serving cell with two uplink carriers with higher layer parameter *supplementaryUplink*. The conditions under which the switching gap may be present are defined for each of the cases in clauses 6.1.6.1, 6.1.6.2, and 6.1.6.3 respectively.< Unchanged parts are omitted >6.1.6.2.2 Uplink switching with 3 or 4 uplink bandsFor 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 with 2, 3 or 4 bands, the behaviour in subclause 6.1.6.2.0 applies when the two bands involved in the uplink switching belong to different uplink serving cells with the parameters *uplinkTxSwitching*, *uplinkTxSwitchingOption* and *uplinkTxSwitching-2T-Mode* beingreplaced by *UplinkTxSwitchingMoreBands, switchingOptionConfigForBandPair* and *switching2T-Mode,* respectively, and the behaviour in subclause 6.1.6.3 with the parameter *uplinkTxSwitching* being replaced by *UplinkTxSwitchingMoreBands* applies when the two bands involved in the uplink switching belong to one uplink serving cell, with the following exceptions:- If more than two bands are involved in the determination of one uplink switching and if on any two of the bands the UE is configured with *switchingOptionConfigForBandPair* set to 'dualUL',< Unchanged parts are omitted > |

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| Company | Comment |
| Moderator (NTT DOCOMO) | According to the discussion in previous meetings, there would still be arguments that RAN1 should discuss whether/how to handle concerned scenario of 1T-1T switching with only 2 bands before agreeing on the proposed TP.In such case, the moderator’s understanding is that all companies are fine with following two points.* UE with only 1 Tx chain is not assumed for UL Tx switching.
* For a UE with 2 Tx chains, if the UE supporting Rel-18 UL Tx switching supports dual UL on band A and B with only 1 port support on each band, the UE is required to support UL-CA for the band combination {A, B} and the UE is not expected to be configured with two-bands UL Tx switching for the band combination {A, B}.

Remaining issue is that for a UE with 2 Tx chains, if the UE supporting Rel-18 UL Tx switching supports **only switched UL on band A and B with only 1 port support on each band**, whether UE can be configured with 2 bands UL Tx switching for band combination {A, B} or UE is not expected to be configured with two-bands UL Tx switching for the band combination {A, B}. Or, we can discuss whether the UE can perform zero-gap switching for the case or not, assuming the UE can be configured with 2 bands UL Tx switching for band combination {A, B}. |
| MediaTek | * We agree with the moderator’s view, and we support the following two points:
	1. UE with only 1 Tx chain is not assumed for UL Tx switching.
	2. For a UE with 2 Tx chains, if the UE supporting Rel-18 UL Tx switching supports dual UL on band A and B with only 1 port support on each band, the UE is required to support UL-CA for the band combination {A, B} and the UE is not expected to be configured with two-bands UL Tx switching for the band combination {A, B}.
* If the UE is configured with only two bands, and the UE supports **only switched UL on band A and B with only 1 port support on each band**, the UE is not expected to be configured with two-bands UL Tx switching for the band combination {A, B}. There is no UL Tx switching occurring in this scenario, and the UL Tx switching framework is not applicable.
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| Moderator (NTT DOCOMO) | In Monday online session, following three alternative proposals were provided but we could not agree on any of them.Alt.1 proposal: to agree on the proposed TPAlt.2 proposal: to agree on either UE can be configured with 2 bands 1T-1T UL Tx switching or UE is not expected to be configured with 2 bands 1T-1T UL Tx switchingAlt.3 proposal: to conclude that there is no consensus in RAN1 on whether UE can be configured with 2 bands 1T-1T UL Tx switching or UE is not expected to be configured with 2 bands 1T-1T UL Tx switchingBased on the offline discussion with several companies after the online session, following is the moderator’s understanding.* It is the fact that 1T-1T switching between 2 bands is not supported/specified in Rel-16/17.
* According to RAN2 agreement, if the UE reports the support of Rel-18 UL Tx switching with 3 or 4 bands (e.g., bands A, B, C) including 2 bands with only 1 port support on each band (e.g., band A and B), it seems that the UE can be configured with 1T-1T UL Tx switching between 2 bands (band A and B) by using Rel-18 UL Tx switching configurations. At least some companies in RAN1 have a concern on supporting such fallback to the scenario which has not been supported.
	+ So, the companies having concern on the scenario would like to have a UE capability to report whether UE supporting Rel-18 UL Tx switching with 3 or 4 bands can fallback to 1T-1T UL Tx switching between 2 bands or not.
	+ Or, the companies are ok to not support the fallback to 1T-1T UL Tx switching between 2 bands.
* On the other hand, at least some other company in RAN1 would like to support the fallback to 1T-1T UL Tx switching between 2 bands. If the fallback is not supported, UL Tx switching configuration is restricted for the UE supporting Rel-18 UL Tx switching with 3 or 4 bands including 2 bands with only 1 port support on each band, and there would be performance loss due to the configuration restriction.
* If the 1T-1T UL Tx switching between 2 bands (A and B) is to be supported by the UE supporting Rel-18 UL Tx switching with 3 or 4 bands including A (1 port) and B (1 port) with switched UL, there may be following two cases.
	+ Case 1: the UE can perform UL Tx switching between A and B with zero switching gap (i.e., each of two Tx chains can be associated with band A and B, respectively)
	+ Case 2: the UE can perform UL Tx switching between A and B with non-zero switching gap (i.e., two Tx chains can only be associated with either A or B at a time)

Based on above, the moderator would like to ask companies to check following way forward and provide feedback.**Proposed way-forward*** Step 1: RAN1 will send LS to RAN4 and RAN2 to check following points.
	+ Whether the UE supporting Rel-18 UL Tx switching with 3 or 4 bands (e.g., bands A, B, C) including 2 bands with only 1 port support on each band (e.g., band A and B) can always support the fallback to 1T-1T UL Tx switching between 2 bands (band A and B) by using Rel-18 UL Tx switching configurations or not
	+ If the fallback cannot be always supported, whether there is any existing capability to report the support of such fallback to 1T-1T UL Tx switching between 2 bands or new capability(es) is/are necessary
	+ For the support of 1T-1T UL Tx switching between 2 bands (A and B) with switched UL, whether both of following cases are possible or not
		- Case 1: the UE can perform UL Tx switching between A and B with zero switching gap (i.e., each of two Tx chains can be associated with band A and B, respectively)
		- Case 2: the UE can perform UL Tx switching between A and B with non-zero switching gap (i.e., two Tx chains can only be associated with either A or B at a time)
	+ Whether additional new capability(es) is/are necessary for Case 1 and/or 2
* Step 2: After RAN1 receives feedback from RAN4 and RAN2, RAN1 will discuss and agree on followings.
	+ TP for 38.214 in R1-2406993 as starting point to align with RAN2/4 specifications to support the fallback to UL Tx switching between 2 bands using Rel-18 UL Tx switching configuration
	+ New capability(es) according to RAN4/2 feedback on Step 1 questions
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| New H3C | Slightly prefer FL’s proposed way-forward |
| Moderator (NTT DOCOMO) | I checked RAN4 reply and corresponding discussion on RAN2 LS at RAN4#110 meeting.<https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_110/Inbox/Chair_Notes/Main_Session_Notes/RAN4_110_Main_Session_report_v10_after-post-meeting-process.docx><https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_110/Inbox/Drafts/%5B110%5D%5B100%5D%20Main%20Session/02.Tuesday/10.%5B129%5D_R4-2401088%20summary%20for%20%5B110%5D%5B129%5D%20NR_MC_enh_UERF_v0.docx>I could not find any note on RAN4 discussion outcome on the concerned scenario (i.e., fallback to 1T-1T switching between 2 bands based on RAN2 agreement).So, it would be worth to ask questions listed in the step 1 of proposed way forward to RAN4/2. |
| Moderator (NTT DOCOMO) | Based on the discussion in Tuesday online session, the proposed way forward can be further updated as below.**Proposed way-forward*** Step 1: RAN1 will send LS to RAN4 and RAN2 to check following points.
	+ For the UE supporting Rel-18 UL Tx switching with 3 or 4 bands (e.g., bands A, B, C) including 2 bands with only 1 port support on each band (e.g., band A and B), whether the UE can be configured with 1T-1T UL Tx switching with just 2 bands (band A and B) by using Rel-18 UL Tx switching configurations or not
	+ If 1T-1T UL Tx switching with 2 bands can be configured to UE supporting Rel-18 UL Tx switching, whether corresponding UE capability (to report whether UE can be configured with 1T-1T UL Tx switching with 2 bands or not) is necessary or not, with considering Rel-16/17 UL Tx switching (1T-2T and 2T-2T switching with 2 bands are supported but 1T-1T switching with 2 bands is not supported) and IoDT aspects (the fallback from 3 or 4 bands to 2 bands is possible as long as 2 bands case could be IoDTed)
		- If UE supports dual UL for the 2 bands with 1 port on each band, whether UE is not expected to be configured with UL Tx switching for the 2 bands or UE can be configured with UL Tx switching for the 2 bands
		- If UE supports only switched UL for the 2 bands with 1 port on each band, whether both of following two cases are possible, and whether additional capability(es) for Case 1 and/or Case 2 is/are necessary or not
			* Case 1: the UE can perform UL Tx switching between A and B with zero switching gap (i.e., each of two Tx chains can be associated with band A and B, respectively)
			* Case 2: the UE can perform UL Tx switching between A and B with non-zero switching gap (i.e., two Tx chains can only be associated with either A or B at a time)
* Step 2: After RAN1 receives feedback from RAN4 and RAN2, RAN1 will discuss and agree on necessary CR for RAN1 specification and UE capability(es)
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| Moderator (NTT DOCOMO) | MTK’s version**Proposed way-forward*** Step 1: RAN1 will send LS to RAN4 and RAN2 to check following points.
	+ For the UE supporting Rel-18 UL Tx switching with 3 or 4 bands (e.g., bands A, B, C) including 2 bands with only 1 port support on each band (e.g., band A and B), whether the UE can be configured with 1T-1T UL Tx switching when just 2 bands configured (band A and B) by using Rel-18 UL Tx switching configurations or not
	+ If 1T-1T UL Tx switching can be configured, when just 2 bands configured, to UE supporting Rel-18 UL Tx switching, whether corresponding UE capability (to report whether UE can be configured with 1T-1T UL Tx switching with 2 bands or not) is necessary or not, with considering Rel-16/17 UL Tx switching (1T-2T and 2T-2T switching with 2 bands are supported but 1T-1T switching with 2 bands is not supported) and IoDT aspects (the fallback from 3 or 4 bands to 2 bands is possible as long as 2 bands case could be IoDTed)
		- It is RAN1 understanding that for a UE with 2 Tx chains, if the UE supporting Rel-18 UL Tx switching supports dual UL on band A and B with only 1 port support on each band, the UE is required to support UL-CA for the band combination {A, B} and the UE is not expected to be configured with two-bands UL Tx switching for the band combination {A, B}.
		- If UE supports only switched UL for the 2 bands with 1 port on each band, whether both of following two cases are possible, and whether additional capability(es) for Case 1 and/or Case 2 is/are necessary or not
			* Case 1: the UE can perform UL Tx switching between A and B with zero switching gap (i.e., each of two Tx chains can be associated with band A and B, respectively)
			* Case 2: the UE can perform UL Tx switching between A and B with non-zero switching gap (i.e., two Tx chains can only be associated with either A or B at a time)
* Step 2: After RAN1 receives feedback from RAN4 and RAN2, RAN1 will discuss further and agree on necessary CR for RAN1 specification and UE capability(es)

QCM’s version?**Proposed way-forward*** Step 1: RAN1 will send LS to RAN4 and RAN2 to check whether there is any issue on followings.
	+ For the UE supporting Rel-18 UL Tx switching with 3 or 4 bands (e.g., bands A, B, C) including 2 bands with only 1 port support on each band (e.g., band A and B), according to RAN2 agreement on fallback to 2 bands UL Tx switching with Rel-18 configurations, it seems that the UE can be configured with 1T-1T UL Tx switching when just 2 bands configured (band A and B) by using Rel-18 UL Tx switching configurations.
	+ There is no consensus in RAN1 whether the fallback to 1T-1T UL Tx switching when just 2 bands configured (band A and B) is regular fallback or not, since it would fall back to a feature that had not been defined either in Rel-18 or before.
	+ Due to at least IODT uncertainties, one possible way is to introduce one bit new Rel-18 UE capability indication to report the support of fallback to 1T-1T UL Tx switching when just 2 bands configured. A single bit per band combination suffices and it applies to all 2-band 1T-1T fallback cases covered by the band combination. Note that the new capability is applicable to only UE capable of Rel-18 UL Tx switching and is not applicable to UE only capable of Rel-16/17 UL Tx switching.
	+ If UE reports the support of UL CA for the 2 bands (band A and B), the new capability is ignored and the UE is not expected to be configured with two-bands UL Tx switching for the band combination {A, B}.
* Step 2: After RAN1 receives feedback from RAN4 and RAN2, RAN1 will discuss further and agree on necessary CR for RAN1 specification and UE capability(es)

HW’s version**Proposal**:As a follow-up of LS R1-2401776 for R18 UL Tx switching, * Agree the simple 38.214 CR and attach it in the LS.
* No technical issue is identified to support R18 RRC configuration of UL Tx switching for two bands, including 1T-1T configuration (i.e. no UL MIMO on either of the two bands). But a concern is raised by two companies for a band pair {A, B} with no UL-MIMO capability that
	+ how to indicate with UE capability for a UE that the UE is additionally capable of “switchedUL” UL Tx switching with non-zero switching gap if the UE is configured with R18 two-band UL Tx switching and no UL-MIMO on both bands.
	+ how to indicate with UE capability for a UE that the UE is capable of normal UL-CA for the same concerned two bands.
	+ [Whether any IoDT issue is identified with the current UE capability signaling to enable the discussed fallback mechanism to the 2-band configuration]
* Ask RAN2 consider the potential UE capability to resolve the concern and provide feedback if any. CC RAN4 (since the 1T-1T case had been raised there before RAN4 agreed the reply LS and the 2-band decision was originated from RAN2).

FL’s version (based on QCM’s version and HW’s comment)**Proposed way-forward*** RAN1 will send LS to RAN4 and RAN2 to check whether there is any issue on followings.
	+ For the UE supporting Rel-18 UL Tx switching with 3 or 4 bands (e.g., bands A, B, C) including 2 bands with only 1 port support on each band (e.g., band A and B), according to RAN2 agreement on fallback to 2 bands UL Tx switching with Rel-18 configurations, the UE can be configured with 1T-1T UL Tx switching when just 2 bands configured (band A and B) by using Rel-18 UL Tx switching configurations.
	+ There is no consensus in RAN1 whether the fallback to 1T-1T UL Tx switching when just 2 bands configured (band A and B) is regular fallback or not.
	+ Due to at least IODT uncertainties concerned by some companies in RAN1, one possible way is to introduce one bit new Rel-18 UE capability indication to report the support of fallback to 1T-1T UL Tx switching when just 2 bands configured. A single bit per band combination suffices and it applies to all 2-band 1T-1T fallback cases covered by the band combination. Note that the new capability is applicable to only UE capable of Rel-18 UL Tx switching and is not applicable to UE only capable of Rel-16/17 UL Tx switching.
	+ If UE reports the support of UL CA for the 2 bands (band A and B), the new capability is ignored and the UE is not expected to be configured with two-bands UL Tx switching for the band combination {A, B}.
* RAN1 will agree on TP for RAN1 specification and will discuss above UE capability
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| Moderator (NTT DOCOMO) | Based on the discussion, FL would like to try to discuss capability design.**FL proposal**Introduce following capability for the support of fallback to 1T-1T UL Tx switching when just 2 bands configured.* FG name
	+ Support of fallback configuration to 1T-1T UL Tx switching by using Rel-18 UL Tx switching configurations when just 2 bands configured
* Component
	+ Support of fallback configuration to 1T-1T UL Tx switching by using Rel-18 UL Tx switching configurations when just 2 bands configured
* Prerequisite
	+ Rel-18 UL Tx switching for 3 or 4 bands
* Consequence if the feature is not supported by the UE
	+ UE is not expected to be configured with 1T-1T UL Tx switching when just 2 bands configured (band A and B) by using Rel-18 UL Tx switching configurations
* Type
	+ Per BC
* Note
	+ None
* Mandatory or optional
	+ Optional with capability signaling
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1. Conclusion