**3GPP TSG-RAN WG4 Meeting #107 R4-23xxxxx**

**Incheon, KR, May 22nd - May 26th, 2023**

**Source: China Telecom**

**Title: Ad-hoc minutes for Rel-18 NR Multi-carrier enhancement**

**Agenda Item: 8.24.4**

**Document for: Approval**

# Topic #1: Tx switching across 3/4 bands with single TAG

### Sub-topic 1-1: Length of switching time for certain scenarios (30 minutes)

#### Issue 1-1-1: Switching case across four bands, i.e., {1T, 1T, 0T, 0T} to {0T, 0T, 1T, 1T}

***Background: WF in RAN4 #106-bis-e***

*Previous Agreement:*

*On the length of switching period:*

* *For UL switching period with Tx switching across 3 or 4 bands, RAN4 agreed to reuse the same set of values as in Rel-16/17, i.e., {35 us, 140 us, 210 us} for UL CA and SUL.*
* *The length of switching period is applied per band pair for each band combination.*
* *For each band pair, the switching period can be the same or different for 1Tx-2Tx switching and 2Tx-2Tx switching based on UE reporting, which is similar as in Rel-17.*
  + *Note: For UE reporting different periods for 1Tx-2Tx switching and 2Tx-2Tx switching for a band pair, similar to Rel-17, it is RAN4 understanding that the 2Tx-2Tx switching period is applied when 2Tx-2Tx switching mode is configured.*
* *Further discuss in the next meeting:*
  + *Option A: As optional UE behaviour, total switching period can be extended if UE is not capable for concurrent TX switching on the two TX chains.* 
    - *Option A1: add new values {70, 175} usec in addition to the agreed set of {35 us, 140 us, 210 us}*
    - *Option A2: Sum of two switching periods*
  + *When UE is scheduled to switch two TX chains in such way that switching periods may overlap, the switching period is extended for both band pairs and total switching time is the sum of possible switching periods for the band pairs involved.*
  + *When UE is scheduled for transmissions so that the switching is from two bands with one TX each to another two bands one TX each, denoted for example A+B to C+D, and it cannot be determined if UE switches TX chains from A to C or D or from B to C or D, the switching time is sum of max{Tswitch\_A-C, Tswitch\_A-D,} and max{Tswitch\_B-C, Tswitch\_B-D}.*
  + *Include clearly the aspect that when two TX chains are switched with different lengths of the switching periods, none of the TX chains are expected to be used for transmissions.*
  + *Option B: Keep the previous agreements*
* **Proposals:**
  + Option A: As optional UE behaviour, total switching period can be extended if UE is not capable for concurrent TX switching on the two TX chains. (vivo, Xiaomi, QC)
    - ~~Option A1: add new values {70, 175} usec in addition to the agreed set of {35 us, 140 us, 210 us}~~
    - Option A2: Sum of two switching periods (vivo, Xiaomi, QC)
  + When UE is scheduled to switch two TX chains in such way that switching periods may overlap, the switching period is extended for both band pairs and total switching time is the sum of possible switching periods for the band pairs involved.
  + When UE is scheduled for transmissions so that the switching is from two bands with one TX each to another two bands one TX each, denoted for example A+B to C+D, and it cannot be determined if UE switches TX chains from A to C or D or from B to C or D, the switching time is sum of max{Tswitch\_A-C, Tswitch\_A-D,} and max{Tswitch\_B-C, Tswitch\_B-D}.
  + Include clearly the aspect that when two TX chains are switched with different lengths of the switching periods, none of the TX chains are expected to be used for transmissions.
    - Option A3: New switching periods capabilities are defined as uplinkTxSwitchingPeriod1T1Tto2T and uplinkTxSwitchingPeriod1T1Tto1T1T per two band pairs (QC)
  + QC:
    - * Allowing UE a longer switching time for {1T,1T,0T,0T} to {0T,0T,1T,1T} case increases UL opportunities and therefore network performance.
      * In RAN1 feasibility study and simulations for 3 and 4 band TX switching, longer switching time for all cases was assumed and throughput gain over 2-band switching case is still achieved
      * If longer switching time is specified for case {1T,1T,0T,0T} to {0T,0T,1T,1T} that is valid only for dualUL, the dualUL network throughput performance over the switchedUL is still much better.
  + Option B: Keep the previous agreements (HW, ZTE, OPPO)
    - HW:
  + Adding new values to the agreed switching period set is not expected.
    - * Rel-18 Tx switching can work well based on the previous agreement without error.
      * Adding new values would increase the complexity from the perspective of network.
  + Sum of two switching periods is not expected.
    - * The illustrated time mask on summing of two switching periods has been precluded in the last meeting since it violate the RAN1 agreement.
      * According to RAN1’s evaluation, too long switching period would results in worse performance for Tx switching than semi-static UL CA or single uplink.
  + The worse optional capability results from the sum of switching periods should not be introduced considering optional capability is equivalent to advanced capability from RAN2’s logic.
    - ZTE: Switching period longer than 210us would cause NW performance degradation
    - OPPO:
  + It is unclear why only 70us and 175us are needed but 140+140, 35+210, 140+210, 210+210 are not needed.
  + Large switch period will make the Tx switching feature no useful.
  + It is UE choice which value among 35us, 140us and 210us will be reported, and if UE cannot do parallel switching of two band pairs then it is free to choose a larger value to cover the whole switching periods.

Discussion:

OPPO: The relationship of the new capability with the already agreed capabilities?

HW: Share the same concern with OPPO. Not necessary to introduce the capability.

QC: the signaling design is up to RAN2.

OPPO: the benefit of the additional signalling is not clear.

HW: Based on the option A3, UE report 210us from Rel-18 A->C (can be different from Rel-16/17 capability for A->C), report 210us for B->D, and report 210us for A+B->C+D

* + why the same value is possible?

QC:

* + QC: Is HW proposing larger new value?
* **Agreement:**
  + Further discuss Option A and Option B in this meeting.
  + From Option A, Option A3 is considered for further discussion:
    - Option A3: As optional UE behaviour, in addition to the previously agreed UE capability on per-band-pair switching period, UE can optionally and additionally report new switching periods capability of uplinkTxSwitchingPeriod1T1Tto1T1T per combination of switching-from bands and switching-to bands.
  + Candidate values are {35u, 140us, 210us}, no other values to be added.
  + For switching from {1T, 1T, 0T, 0T} to {0T, 0T, 1T, 1T} on band {A, B, C, D},
    - * switching-from bands are A+B
      * switching-to bands are C+D
  + UE to report one value for each combination of switching-from bands and switching-to bands.
  + This new capability only applies for switching of 2Tx chains between 2 different band pair as a switching event, i.e., {1T, 1T, 0T, 0T} to {0T, 0T, 1T, 1T}, and the previous agreed capability applies unless otherwise stated.

For the understanding of the option A3 (to be captured in the WF for information purpose)

* For switching from {1T, 1T, 0T, 0T} to {0T, 0T, 1T, 1T} on band {A, B, C, D},
* Based on the previous agreement, UE report 35us for A->C, and report 35us for B->D, then 35us will be used for A+B -> C+D.
* Based on the option A3, UE report 35us from Rel-18 A->C (can be different from Rel-16/17 capability for A->C), report 35us for B->D, and report 140us for A+B->C+D, then
  + 35us will be used for switching {1, 0, 0,0} to {0, 0, 1,0}.
  + 140us will be used for switching {1, 1, 0,0} to {0, 0, 1, 1}.

#### Issue 1-1-2: Switching case across three bands, i.e., {1T, 1T, 0T} to {0T, 0T, 2T}

***Background: WF in RAN4 #106-bis-e***

* *Further discuss in the next meeting:*
  + *Option A: As optional UE behaviour, total switching period can be extended if UE is not capable for concurrent TX switching on the two TX chains.*
    - *Option A1: add new values {70, 175} usec in addition to the agreed set of {35 us, 140 us, 210 us}*
    - *Option A2: Sum of two switching periods*
  + *When UE is scheduled to switch two TX chains in such way that switching periods may overlap, the switching period is extended for both band pairs and total switching time is the sum of possible switching periods for the band pairs involved.*
  + *Option B: Keep the previous agreements*
* **Recommended WF:** 
  + If any further conclusion can be made for Issue 1-1-1, it applies to Issue 1-1-2 as well.

Agreement:

* + If any further conclusion can be made for Issue 1-1-1, it applies to Issue 1-1-2 as well.

#### Issue 1-1-3: The unaffected band case

***Background: WF in RAN4 #106-bis-e****:*

* *Further discuss in the next meeting:*
  + *Option 1: When UE is scheduled for UL transmissions on any band other than the bands involved in switching, the switching time is the sum of switching periods indicated for the band pair involved in switching and the band pair including the unaffected band and the switch-to band*
  + *Option 2: For the two band pairs switching with one common band, e.g., band pair A+B and band pair B+C, the band B is involved in switching event and it is not the unaffected band.*
  + *Option 3: The previous agreement should be reused*
* **Proposals:**
  + Option 1: When UE is scheduled for UL transmissions on any band other than the bands involved in switching, the switching time is the **sum** of switching periods indicated for the band pair involved in switching and the band pair including the unaffected band and the switch-to band (vivo)
  + Option 2: When another band unaffected by the switching is transmitting while switching between two other band occur, the switching period is **double** the value declared by the UE for these bands. (QC)
  + Option 3: The previous agreement should be reused (HW, ZTE, OPPO)
* **Recommended WF:** 
  + Further discuss.

### Sub-topic 1-2: 2-layer UL-MIMO support for carrier(s) capable of 2Tx (20 minutes)

***Background: WF in RAN4 #106-bis-e*:**

* *Further discuss in the next meeting:*
  + *Option 1: Mandate 2-layer UL-MIMO support for carrier(s) capable of 2Tx*
    - *DCM: RAN2 agreed that UL MIMO capability is used for UE to indicate 2Tx support. It means that UE need to indicate UL MIMO capability if UE wants to indicate 2Tx capability.*
  + *For UE capability of 2-port UL transmission, RAN2 reuse the per-FS UL-MIMO UE capability (no spec change).*
  + *Option 2: Not mandate 2-layer UL-MIMO support for carrier(s) capable of 2Tx*
* **Proposals:**
  + Option 1: Mandate 2-layer UL-MIMO support for carrier(s) capable of 2Tx (China Telecom, NTT DOCOMO)
    - China Telecom: considering the aspects that: 1) UL throughput benefit, 2) moderate complexity increase, 3) specification consistency with the Rel-16/17 Tx switching, 4) specification consistency with RAN2 for Rel-18 Tx switching.
    - DCM: RAN2 agreed that UL MIMO capability is used for UE to indicate 2Tx support. It means that UE need to indicate UL MIMO capability if UE wants to indicate 2Tx capability.
  + *For UE capability of 2-port UL transmission, RAN2 reuse the per-FS UL-MIMO UE capability (no spec change).*
  + Option 2: Not mandate 2-layer UL-MIMO support for carrier(s) capable of 2Tx (vivo, Apple)
    - Apple:
  + Tx switching and UL-MIMO features are configured differently in the Release 18 specifications and should be independently implemented to allow flexibility.
  + There are implementation and cost challenges for implementing UE UL-MIMO feature. This could make this feature optional, and not mandatory.
  + In the current Release 18 specifications, the UL-MIMO feature is only defined for a limited number of NR bands whereas there are several UL CA combinations that do not involve UL-MIMO bands.
  + The RF requirements in Release 18 are grouped separately for UL-MIMO and TxD and the corresponding requirements are defined in different clauses.
* **Recommended WF:** 
  + Further discuss.

Ad-hoc chair: Any concern on option 1?

Apple: still prefer option 2.

vivo: whether there is any spec impact on the option 1?

QC: UE can support TxD as well, and baseband complexity need to be considered.

Vivo: We an accept option 1 considering the situation in Rel-16/17. But it should keep in mind it is not typical to link two separate features.

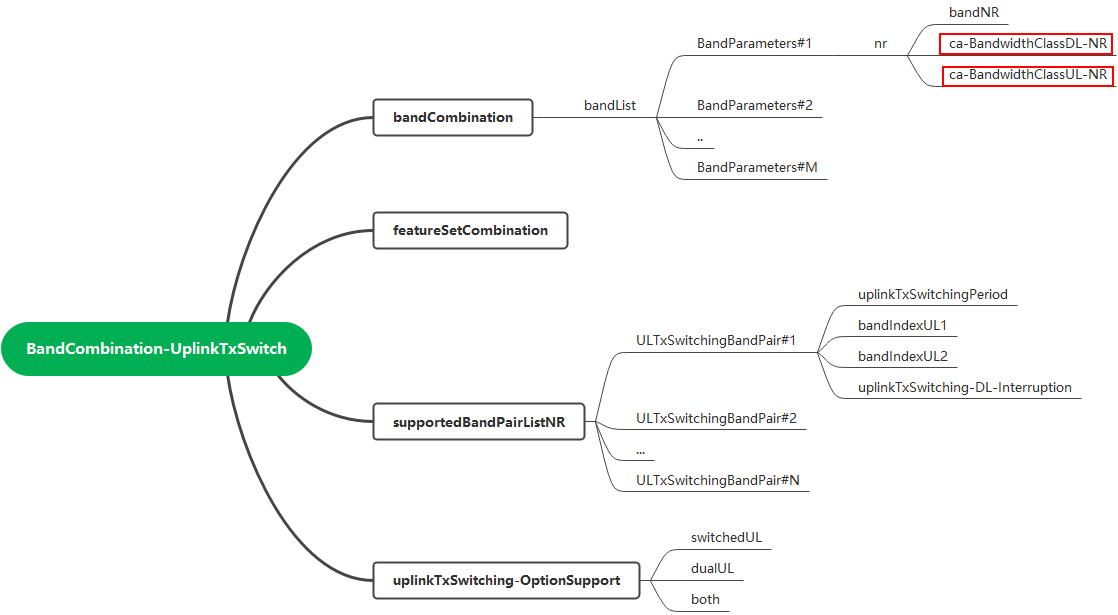
HW: For option 1, 1-layer transmission can still be used based on network scheduling.

Agreement:

* + Further discuss Option 1 and option 2.
  + If option 2 is considered in RAN4, additional spec effort is required in RAN2.

### Sub-topic 1-3: Band configurations for Rel-18 Tx switching (20 minutes)

* Proposals:
  + Option 1: No need to introduce the band configurations for Rel-18 Tx switching in RAN4 specification, which means all existing *band* configurations can support Rel-18 Tx switching based on optional UE capability (Huawei, China Telecom, NTT DOCOMO)
    - Huawei:
  + Band combinations along with UL configuration are up to the operators’ demand. And the existing CA/SUL band combinations can be reused for Rel-18 Tx switching.
  + The network would schedule the switching between band pairs for a band combination according to the reported band pairs and UL configurations. And the network can avoid scheduling Tx switching that result in concurrent transmission for two bands without UL CA configuration.
  + Rel-18 should introduce Tx switching capability per band combination.



* + - China Telecom:
  + The band combinations supporting Rel-18 Tx switching across 3/4 bands are up to UE implementation and reporting.
  + No BC specific requirement for Rel-18 Tx switching is needed. For the use of Tx switching across 3/4 bands, the generic Rel-18 Tx switching requirement (i.e., CR endorsed in RAN4 #106) and the existing CA/SUL BC specific requirements are sufficient.
  + When there are necessary BC specific RF requirements to be discussed and specified, e.g., DL interruption due to Tx switching, we support to discuss the requirement per BC basis and capture the agreement in the RAN4 specification.
  + Option 2: for the ease of implementation, we propose that band configurations for UL Tx switching across 3 and 4 bands should be included in the specifications. (Apple, Ericsson, Qualcomm)
    - Observation #1: In the current specifications (see Table 5.5A.3.2-1 and Table 5.5A.3.3-1) there are 3-band and 4-band CA combinations where there are no band pairs configured for UL CA. Therefore, UL Tx switching cannot be configured for those band combinations.
    - Observation #2: Not all the band pairs within a 3-band or 4-band CA combination can be configured for UL Tx switching because in the current specifications there are 3-band and 4-band CA combinations where only some band pairs are configured for UL CA. (see Table 5.5A.3.2-1 and Table 5.5A.3.3-1).
    - Observation #3: For every band pair configured for UL Tx switching within the 3-band or 4-band CA combination, the switching mode (0Tx+2Tx, 2Tx+0Tx, 1Tx+1Tx) should be defined, based on the UL MIMO capability on each band.
  + Option 3: Not to introduce a new table but to introduce a new column or NOTE into existing band configuration tables to indicate which band combination can support Rel-18 Tx switching, and the indication in the specification can be updated directly by submitting CR, which means we don’t need to follow a basket WI approach. (NTT DOCOMO)
* **Recommended WF:** 
  + Companies are firstly encouraged to check if there is any technical misunderstanding for the Observation #1 and #2 under Option 2, especially considering the following text from the RAN4 endorsed CR:

*For each uplink band pair, according to the capability [uplinkTxSwitching-OptionSupport],*

*– if* ***switchedUL is supported****, uplink transmission on any one band of the band pair in the band combination shall be supported according to the scheduling commands, and* ***the corresponding inter-band CA requirements with one UL band on band X or band Y shall be satisfied****;*

*– if* ***dualUL is supported****, simultaneous uplink transmission on the two NR UL bands from the band pair for which dualUL is declared in the band combination shall be supported according to the scheduling commands, and* ***the corresponding inter-band CA requirements with two uplink bands shall be satisfied****.*

Ad-hoc chair:

From band A+B+C, UE support switchedUL on 3 band pair: A+B, B+C, A+C

* UE apply the DL CA requirements of DL on A+B+C and UL on band A, B, C respectively.

### Sub-topic 1-3A: Band configurations for DL interruption due to Rel-18 Tx switching (10 minutes)

* **Proposals:**
  + Option 1: Adding DL interruption applicability to the Table 5.2A.2.3-1 for the 4-band CA combinations. (Apple)

|  |  |  |
| --- | --- | --- |
| ***NR CA band combination*** | ***NR Bands*** | ***DL interruption allowed*** |
| CA\_n1-n3-n28-n78 | n1, n3, n28, n78 | No for CA\_n1-n78, CA\_n3-n78 |
| CA\_n3-n41-n77-n79 | N3, n41, n77, n79 | No for CA\_n3-n41 |

***Table 2.1.3: Examples of 4-band CA combinations with DL interruption not allowed***

* **Recommended WF:**
  + Encourage feedback.

**Discussion:**

MTK:

From DL interruption perspective, from band A+B+C, UE support switchedUL on A+B, UE has 2nd Tx chain fixed on the band C. No matter switch-from or switch-to, there maybe uplink IMD impact on third DL band. The existing band combination table and singalling do not tell this impact.

E///: How can we define the DL interruption tables without UL Tx switching table?

HW: why we cannot agree the yellow part?

QC: Without a new table, it is not clear 3-band or 4-band can be configured in the uplink since we only have tables for 2-UL bands.

The green highlighted part is agreed, and further discuss the yellow highlighted part:

* Band configurations for Rel-18 Tx switching
  + All the existing band combinations can support Rel-18 Tx switching based on optional UE capability
  + Add generic statement in TS 38.101-1 to clarify that 3-band or 4-band can be configured in the uplink without the tables/requirements on concurrent transmission on the 3/4 UL bands.
* Further discuss where to add the generic statement:

Option 1: Add generic statement in the following tables

* + For CA band configurations: Table 5.5A.3.2-1, Table 5.5A.3.3-1
  + For CA+SUL band configurations: Table 5.5C-4, Table 5.5C-5

Other options are not precluded.

Agreement:

* Band configurations for DL interruption due to Rel-18 Tx switching
  + Adding DL interruption applicability to the tables for the 3-band and 4-band CA combinations for Tx switching across 3-band and 4-band
  + The existing DL interruption applicability only applies when only 2 uplink bands are configured.

### Sub-topic 1-5: Switching case across three bands, i.e., switch between {1T, 1T, 0T} and {0T, 0T, 2T} (Discuss if time allows)

#### Issue 1-5-1: Advanced optional UE ability

* ***Background: WF in RAN4 #106-bis-e***
  + *Option 1: For the switching scenario without ambiguity, i.e., the two Tx chains are on the same band before or after switching (switch between {1T, 1T, 0T} and {0T, 0T, 2T}), introduce advanced optional UE ability to allow the Tx chain #1 to be used for transmission during the time duration of (Tswitch\_2 - Tswitch\_1).*
    - *Tswitch\_1 and Tswitch\_2 are the switching periods of Tx chain #1 and Tx chain #2 respectively,and Tswitch\_1 < Tswitch\_2.*
    - *Option 1a: apply the same UE capability for this scenario and for the following scenario agreed in the previous meetings. (MTK, China Telecom, ZTE)*

*RAN4 LS approved in R4-2303507:*

*When one of the two Tx chains is triggered to switch from one band (named “band A”) to another band (name “band B”), the other Tx chain is maintained on a different band (named “band C” or “band D” in the case of 4-band) and the number of Tx chain on band C or band D is unchanged due to the switching, RAN4 agreed the granularity of the optional UE capability to allow UL transmission on the band with the number of Tx chain unchanged during UL switching as follows:*

* *Per band (only for the band(s) in the band combination but not included in the pair of bands before and after switching) for each pair of bands before and after switching in each band combination.*
  + *Option 2: Not introduce advanced optional UE ability*
* **Proposals:**
  + Option 1: For Tx switching between {1T, 1T, 0T} and {0T, 0T, 2T}, introduce advanced optional UE ability to allow the Tx chain #1 to be used for transmission during the time duration of (Tswitch\_2 - Tswitch\_1) (China Telecom, ZTE)
    - Tswitch\_1 and Tswitch\_2 are the switching periods of Tx chain #1 and Tx chain #2 respectivelyand Tswitch\_1 < Tswitch\_2.
    - Apply the same UE capability with the same granularity for this scenario and for the scenario approved in RAN4 LS in R4-2303507.
  + Option 2: Not introduce advanced optional UE ability (vivo)
* **Recommended WF:**
  + Further discuss.

### Sub-topic 1-6: Switching case across four bands, i.e., {1T, 1T, 0T, 0T} to {0T, 0T, 1T, 1T} (Discuss if time allows)

#### Issue 1-6-1: Ambiguity issue

* ***Background: WF in RAN4 #106-bis-e***
  + *RAN4 maintains the baseline assumption in Issue 1-2-3 agreed in R4-2220546 during RAN4#105.*
  + *Neither of the two Tx chains is expected to be used for transmission during the switching periods in Rel-18*
  + *Encourage companies to study the benefit to resolve the switching pattern ambiguity issue when 2 Tx chains are switched between two different band pairs for one Tx switching instance*
    - *At least for single TAG*
    - *FFS whether it applies to dual TAG*
* **Views on the benefit:**
  + View #1: If the UE is able to perform Tx switching with the band pairs that are corresponded to shorter switching period, the UE could utilize more resources to transmit uplink signal/channels compared to baseline. (HW, ZTE, MTK)
  + View #2: There is no clear benefit to solve this no harm “ambiguity”. (OPPO)
    - OPPO: There is no benefit when the two Tx chain switching periods are same. The benefit only shows when one of the Tx chain needs to be reloaded for all components, i.e. 210us applied for this chain and 140us apply for the other chain. And this is corner case.
* **Proposals on the solutions to resolve the switching pattern ambiguity issue:**
  + Option 1: For the parallel switching of two Tx chain in the case {1T, 1T, 0T, 0T} to {0T, 0T, 1T, 1T} on bands {A, B, C, D}, in addition to the baseline UE assumption agreed in RAN4 #105, introduce optional UE capability with the switching period **min** {max(Tswitch\_A-C, Tswitch\_B-D), max(Tswitch\_A-D, Tswitch\_B-C)}. (HW)
  + Option 2: RAN4 to agree on the **band ordering** based approach to resolve the ambiguity issue. (MTK)
    - Associating the ordering of bands for defining switch-from and switch-to pairs in switching configuration commands may resolve the ambiguity issue without additional cost.
  + Option 3: Introduce new Tx switching period capability **for the switched case** from A+B to C+D and other band group pairs before and after switching. (OPPO)
  + Option 4: Introduce new **per Tx chain-based** Tx switching capability (OPPO)
* **Recommended WF:**
  + Further discuss

#### Issue 1-6-2: Advanced optional UE ability

* ***Background: WF in RAN4 #106-bis-e***
  + *For the switching scenario of {1T, 1T, 0T, 0T} to {0T, 0T, 1T, 1T} on bands {A, B, C, D}, discuss and decide whether or not to introduce the advanced optional UE ability to allow one Tx chain to start transmission earlier if the switching time for this Tx chain is shorter.*
* **Proposals:** For the switching scenario of {1T, 1T, 0T, 0T} to {0T, 0T, 1T, 1T} on bands {A, B, C, D}, with the ambiguity issue **resolved** or **unresolved**
  + Option 1: not to introduce the advanced optional UE ability to allow one Tx chain to start transmission earlier if the switching time for this Tx chain is shorter. (vivo)
* **Recommended WF:**
  + Is option 1 agreeable?

# Topic #3: Reply LS to RAN2

### Sub-topic 3-1: RAN4 Answer to Question 1 (10 minutes)

**RAN2 Question 1:**

*RAN2 has discussed introduction of UE capability for length of switching periods. RAN2 has taken following RAN4 agreement in RAN4#104-e into account.*

|  |
| --- |
| *Agreement:*  *On the length of switching period:*   * *For UL switching period with Tx switching across 3 or 4 bands, RAN4 agreed to reuse the same set of values as in Rel-16/17, i.e., {35 us, 140 us, 210 us} for UL CA and SUL.* * *The length of switching period is applied per band pair for each band combination.* * *For each band pair, the switching period can be the same or different for 1Tx-2Tx switching and 2Tx-2Tx switching based on UE reporting, which is similar as in Rel-17.*   + *Note: For UE reporting different periods for 1Tx-2Tx switching and 2Tx-2Tx switching for a band pair, similar to Rel-17, it is RAN4 understanding that the 2Tx-2Tx switching period is applied when 2Tx-2Tx switching mode is configured.* |

*RAN2 could not achieve conclusion, but has agreed an intention below in RAN2#121bis-e:*

|  |
| --- |
| * *In support of RAN4 agreement, RAN2 intend to introduce support for two per-band-pair UE capabilities, a length of a switching period, for 1Tx-2Tx switching (like Rel-16) and that for 2Tx-2Tx switching (like Rel-17).* |

*Question 1. (To RAN1 and RAN4)*

*RAN2 respectfully asks RAN1 and RAN4 to take above agreement on RAN2 intention into account* *and asks for feedback if there is any issue.*

* **Proposals on RAN4 Answer to Question 1**
  + Option 1: RAN4 agrees with the above agreement on RAN2 intention. (China Telecom, NTT DOCOMO, vivo)
    - Option 1a (China Telecom): In addition, as described in an earlier RAN4 LS in R4-2303507, RAN4 also discussed the scenario of 1Tx-1Tx switching, i.e., the UL carriers in both bands before and after switching are capable of one transmit antenna connector, and agreed to apply the same length of switching period for 1Tx-1Tx switching and 1Tx-2Tx switching. It means that for the band pair supporting 1Tx-2Tx switching, the UE always support 1Tx-1Tx switching with the same length of switching period.
* **Recommended WF:**
  + Option 1 is agreeable, and further discuss whether to add the information in Option 1a in the reply LS.

### Sub-topic 3-2: RAN4 Answer to Question 2 (15 minutes)

**RAN2 Question 2:**

*RAN2 could not conclude whether the UE needs to explicitly report if it supports 2Tx-2Tx switching for every band pair used for Rel-18 UL Tx switching.*

*RAN2 is not sure which is the correct understanding:*

* *The UE always supports 2Tx-2Tx switching on a pair of bands if the UE supports 2 layers/ports UL MIMO on the two bands*
* *The UE may not support 2Tx-2Tx switching on a pair of bands even if the UE supports 2 layers/ports UL MIMO on the two bands (i.e., per-band-pair UE capability to report whether to support 2Tx-2Tx switching is needed, e.g. based on the presence/absence of 2Tx-2Tx switching period).*

*Question 2. (To RAN4)*

*RAN2 respectfully asks RAN4 to take below RAN2 assumptions into account and asks for feedback if there is any issue:*

* *For the band pair supporting 2Tx-2Tx switching, the UE always support 1Tx-2Tx switching.*
* *The UE reports whether it supports 2Tx-2Tx switching via per-band-pair UE capability.*
* **Proposals on RAN4 Answer to Question 2**
  + Option 1: RAN4 agrees with the above two bullets in RAN2 assumptions. (China Telecom, ZTE, vivo)
  + Option 2: (NTT DOCOMO)
    - For 1st bullet in question 2, RAN4 confirms that it has no issues from RAN4 perspective.
    - For 2nd bullet question 2, RAN4 confirm the following: The UE always supports 2Tx-2Tx switching on a pair of bands if the UE supports 2 layers/ports UL MIMO on the two bands
* **Recommended WF:**
  + For 1st bullet in question 2: RAN4 agrees with this bullet
  + For 2nd bullet in question 2: further discuss

### Sub-topic 3-3: RAN4 Answer to Question 3 (15 minutes)

**RAN2 Question 3:**

*RAN2 has discussed how the gNB knows which of the reported switching periods (for 1Tx-2Tx switching or for 2Tx-2Tx) should be applied for every switching but could not conclude.*

*Question 3. (To RAN4)*

*RAN2 respectfully asks RAN4 which of the options below matches RAN4 understanding on the selection of applied switching periods when both switching periods of 2Tx-2Tx switching and 1Tx-2Tx switching can be reported for the same band pair.*

*Option 1: Based on implicit rules, e.g. 2Tx-2Tx switching period is only applicable when performing UL switching between two bands (e.g. 2P+0P<=>0P+2P) and 1Tx-2Tx period is applied for the other switching cases (e.g. UL Tx switching that involves 3 or 4 bands, such as band A + band B<=>band C, band A+ band B <=>band C + band D). FFS on the switching case of 2P+0P<=>1P+1P.*

*Option 2: Based on explicit RRC configuration, i.e., gNB configures which period is applied. FFS on the granularity of the configuration.*

*Question 4. (To RAN1)*

*RAN2 respectfully asks RAN1 to take above discussion on RAN2 and question to RAN4 into account and asks for feedback if there is any issue.*

* **Proposals on RAN4 Answer to Question 3**
  + Option 1: The option 1 above matches RAN4 understanding. (NTT DOCOMO, ZTE)
  + Option 2: The option 2 above matches RAN4 understanding. (China Telecom, vivo)
* **Recommended WF:**
  + Further discuss