3GPP TSG RAN WG2 #121bis-e R2-23xxxxx

Electronic meeting, 17th – 26th April 2023

**Source: NTT DOCOMO, INC.**

**Title: Summary of [AT121bis-e][021][MCE] UL TX Switching (NTT Docomo)**

**Document for: Discussion and decision**

**Agenda Item: 7.25.2**

## Introduction

This document is to report on the following offline discussion:

* [AT121bis-e][021][MCE] UL TX Switching (NTT Docomo)

 Scope: Attempt progress on P6 from R2-2302730

 Intended outcome: Report with agreeable proposal and/or other way forwards.

 Deadline: CB W2 Tuesday

## Contact Points

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## Discussions

In the POST-121 e-mail discussion, companies shared their view on UE capability for length of switching period ([1], 3.3.2). Please find Annex to see all discussion and comments then. The suggested proposal is following.

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| Proposal 6. Continue discussion to down-select from following alternatives.**Alt.1: RAN2 introduce one per-band-pair UE capability to report a length of a switching period.****Alt.2a: RAN2 introduce 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). If the UE supports both 1T-2T and 2T-2T switching for the band pair, the UE shall report both capabilities.****Alt.2b: RAN2 introduce 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). If the UE supports both 1T-2T and 2T-2T switching for the band pair, the UE can report- both capabilities.- either of capabilities to be applied to both switching. (FFS on which is reported.)** |

We recommended continuing discussion and sharing views on which alternative to down-select.

We thank some companies for elaborating proposals responding to P6 in their contributions [2-5].

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| TDoc # | Company | Proposals |
| R2-2302578 | OPPO | Proposal 1 For P6 from [Post121][045], adopt Alt-1, and the UE is mandatory to include the switching period value even if the value is the same as R16/17 2-band switching. |
| R2-2302714 | CATT | Proposal 5: RAN2 to agree on introducing two per-band-pair capabilities for reporting the switching period for 1T-2T and 2T-2T respectively for Rel-18 switching.Proposal 6: If the UE supports both 1T-2T and 2T-2T switching for the band pair, UE can only report the capability for switching period of 1T-2T if the capability for the switch period of 2T-2T is the same as that for the switch period of 1Tx-2T. |
| R2-2303293 | ZTE | Proposal 3 If separate switching periods are defined for 1Tx-2Tx and 2Tx-2Tx, RAN2 confirms that:- Only 1Tx-2Tx switching periods are considered when triggering UL Tx switching among 3 or 4 bands. - 2Tx-2Tx switching period is considered only when triggering 2Tx-2Tx UL Tx switching between 2 bands.Proposal 4 Alternatively, to define a single switching period for each band pair, do not differentiate 1Tx-2Tx or 2Tx-2Tx. |
| R2-2303825 | vivo | Proposal 2 RAN2 introduce 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). If the UE supports both 1T-2T and 2T-2T switching for the band pair, the UE shall report both capabilities. |

In the first online session in this meeting, however, we had no time to properly discuss on P6. In this offline discussion, it should be straightforward to start with just asking preference based on P6.

**Question: Which is your preference on the structure of UE capability for length of switching period(s)?**

**Alt.1: RAN2 introduce one per-band-pair UE capability to report a length of a switching period.**

**Alt.2a: RAN2 introduce 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). If the UE supports both 1T-2T and 2T-2T switching for the band pair, the UE shall report both capabilities.**

**Alt.2b: RAN2 introduce 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). If the UE supports both 1T-2T and 2T-2T switching for the band pair, the UE can report
- both capabilities.
- either of capabilities to be applied to both switching. (FFS on which is reported.)**

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| Company |  Preference  | Comments |
| Docomo | Alt.2b | As we commented in the POST-121 e-mail discussion, RAN4 agreed that UE can report both 1Tx-2Tx period and 2Tx-2Tx period for Rel-18 switching. We would like to refer to the endorsed CR in RAN4 (R4-230719):

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| For each band pair, the length of uplink switching period X is indicated by UE capability [uplinkTxSwitchingPeriod1T-r18] when 1Tx-1Tx switching or 1Tx-2Tx switching between the two bands in the band pair is supported and configured, or is indicated with [uplinkTxSwitchingPeriod2T-r18] when 2Tx-2Tx switching between the two bands in the band pair is supported and configured. |

Therefore, at least RAN2 have to introduce two signals for switching periods, corresponding to 1Tx-2Tx switching and 2Tx-2Tx switching, i.e., we have to exclude Alt.1. (Note that a switching period for 1Tx-1Tx switching is always same as that for 1Tx-2Tx switching reported for the same band pair, thus additional capability for period length of 1Tx-1Tx switching is not needed.)For comparison between Alt.2a and Alt.2b, we think Alt.2b is slightly better because Alt.2b allows to reduce signalling overhead to avoid duplicated reporting if the lengths for 1Tx-2Tx switching and 2Tx-2Tx switching are identical, but this is not a strong preference (we are ok with Alt.2a as well). |
| OPPO | Alt1 with comment | We tend to see Alt1 is also feasible and simpler since the UE can anyway report the longer value of the two cases. While we are open to Alt-2a if there is majority view. We do not see the complexity of Alt-2b (reporting either of the two) is justified, essentially it has no difference compared to Alt-1.. |
| ZTE | Alt1 or Alt2a with comment | We think there are two issues involved:1. For a band pair in which 2 bands both support 2-layer UL MIMO, whether UE can only support 1Tx-2Tx but not 2Tx-2Tx? if the UE can, how to indicate the support of 2Tx-2Tx?
2. Which switching period the network should look at when the switching involves 3/4 bands?

For issue 1, in Rel-17, the UE is allowed to not support 2Tx-2Tx, and it is implicitly indicated by the presence/absence of 2Tx-2Tx switching period, see below sentence in field description:“If the UE does not support 2Tx-2Tx switching for a given band pair, the field of *uplinkTxSwitchingPeriod2T2T* in the corresponding entry is absent.”If we want to follow the same mechanism, then Alt.2a can be considered, the absence of 2Tx-2Tx switching period means the UE does not support 2Tx-2Tx for this band pair. (Alt.2b cannot achieve this purpose).If we go for Alt1, it means the network can rely on the MIMO capability in order to determine whether the UE supports 2Tx-2Tx switching. (This principle is different from Rel-17, but it works.) For issue 2, as we mentioned in R2-2303293. If Alt.1 is adopted, there is no problem. But if Alt.2 is adopted, then we think 2Tx-2Tx switching period is only applicable when the network triggers UL Tx switching between 2 bands (A->B), as long as the switching involves 3 or 4 bands, only 1Tx-2Tx switching period will be considered. (we share the same view as OPPO that 1Tx-1Tx switching period is same as 1Tx-2Tx switching period).To be more specific, in our understanding, the Alt 1 and Alt.2a are:**Alt.1: RAN2 introduce one per-band-pair UE capability to report a length of a switching period.*** **For a band pair, the support of 2Tx-2Tx UL Tx switching is indicated by the support of 2-layer UL MIMO capability of the two bands.**

**Alt.2a: RAN2 introduce 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). If the UE supports both 1T-2T and 2T-2T switching for the band pair, the UE shall report both capabilities.*** **The absence of 2Tx-2Tx switching period means the UE does not support 2Tx-2Tx UL Tx switching;**
* **When triggering UL Tx switching involves 3 or 4 bands (e.g. A+B->C, C->A+B, A+B->C+D), only 1Tx-2Tx switching period will be considered by the network.**
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| Qualcomm Incorporated | Alt2a | Alt2b can be enhanced to address ZTE’s point above, e.g. by introducing CHOICE structure where a “common” capability OR “independent” capabilities can be signalled. |
| CATT | See comment | We think companies may prefer introducing two capabilities for 1T-2T/2T-2T switching period respectively (**Alt.2a**). However, the very beginning issue about this question should be how the UE reports supporting 1T-2T/2T-2T switching option for Rel-18 because the switching period may be used to indicate the capability of switching option. Then the next issue is to discuss how UE indicates the 1T-2T switching period and 2T-2T switching period if UE supports the corresponding switching option for rel-18. However, no company has raised that potential issue, now the question is just associated to how the UE report the switching period in case the UE supports both 1T-2T and 2T-2T switching for the band pair.In our view, UE indicating the supporting of 1T-2T Tx switching on a band pair for Rel-18 is not needed if UE supports that band pair. (It is similar to Rel-17) So, the capability of 1T-2T switching period for Rel-18 should not be used for indicating UE supporting 1T-2T switching option on the band pair. However, we think that capability is necessary, in order to indicate a **different value** **compared to 1T-2T switching period for Rel-16/17**. That means 1T-2T switching period for Rel-16/17 can be reused by Rel-18. We propose:* **Introduce an optional capability of 1T-2T switching period for Rel-18.**
* **If the 1T-2T Tx switching period for Rel-18 is different to that for Rel-16/17 on the same band pair, UE reports the capability of 1T-2T Tx switching period for Rel-18.**

On the other hand, we think the capability of 2T-2T switching period for Rel-18 should be used to indicate the support for 2T-2T switching option on a band pair, because 2T-2T switching is not necessarily be supported by Rel-18. That means UE should report the capability of 2T-2T switching period for Rel-18 if only UE supports the switching option. (also similar to Rel-17) So, we propose:* **Introduce an optional capability of 2T-2T switching period for Rel-18.**
* **UE reports the capability of 2T-2T switching period for Rel-18 if UE supports 2T-2T switching on the band pair.**
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| Huawei, HiSilicon | Alt1 or Alt2a | Regarding ZTE’s Q1 “For a band pair in which 2 bands both support 2-layer UL MIMO, whether UE can only support 1Tx-2Tx but not 2Tx-2Tx? if the UE can, how to indicate the support of 2Tx-2Tx?”, based on RAN1 discussion, we understand RAN1 do not consider the case that 2-layer are supported on both bands, but only 1Tx-2Tx switching is supported while 2Tx-2Tx switching is not supported. So we agree that MIMO layer can be used to differentiate 2Tx-2Tx/1Tx-2Tx/2Tx-1Tx/1Tx-1Tx switching. Following R17 agreement, the band pair supporting 2Tx-2Tx switching also supports 1Tx-2Tx/2Tx-1Tx switching. Then regarding the switching period reporting, like in Rel-17, in order to allow different (smaller) switching period reporting, both of the switching periods of 1Tx-2Tx and 2Tx-2Tx need to be present. But if we want to simplify the Rel-18 UE capability reporting by only defining one switching period which is applicable to 2Tx-2Tx/1Tx-2Tx/2Tx-1Tx/even 1Tx-1Tx switching, we are also fine. In this sense, alt1/alt2a/alt2b all can work, but we understand alt2b may define how NW interprets the UE cap when xx cap parameter is absent, then it seems easier to have two parameters directly as alt.2a.Regarding ZTE’s Q2 “Which switching period the network should look at when the switching involves 3/4 bands?”, our understanding in alt.1 one period applies to all switching cases (2Tx-2Tx/1Tx-2Tx/2Tx-1Tx/1Tx-1Tx) no matter the switching is between 2 bands or among 3/4 bands, while in alt. 2 network needs to determine: when only 2Tx-2Tx is to be performed, 2Tx-2Tx switching period is applied; and for other cases, the longest switching period from all the possible switching behavior applies. In this sense, alt.1 seems to be easier.Meanwhile like Rapp indicated, it seems RAN4 already assume that two switching periods can be reported in Rel-18, if alt1 is to be adopted we need to inform RAN4, which can via LS or info exchange by companies internally. |
| vivo | Alt1 or Alt2a | Agree with ZTE and HW that both Alt1/2a are suitable option, and considering the case where 2Tx-2Tx may not happen when switching across 3/4 bands as ZTE pointed out, we tend to slightly prefer Alt1. If Alt1 is pursued, we should inform RAN4. If there is any concern for Alt1, Alt2a is always a baseline option. |
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## Summary and proposal

TBD

## References

[1] R2-2302730, “Summary of [Post121][045][MCE] UL TX Switching (Docomo),” NTT Docomo, Inc, RAN2#121bis-e.

[2] R2-2302578, “Discussion on R18 UL Tx switching,” OPPO, RAN2#121bis-e.

[3] R2-2302714, “Discussion on Rel-18 UL Tx Switching,” CATT, RAN2#121bis-e.

[4] R2-2303293, “Discussion on Rel-18 UL Tx switching capability,” ZTE, RAN2#121bis-e.

[5] R2-2303825, “discussion on UE capability and RRC configuration for UL tx switching,” vivo, RAN2#121bis-e.

## Annex: Discussion in [Post121][045][MCE] UL TX Switching (Docomo)

## UE capability for length of switching period

**Background**

RAN4 has sent an LS [5] to RAN2 including following description:

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| **Issue 1: Exact value of Tx switching period for each band pair**RAN4 discussed the exact value of Tx switching period for each band pair in the band combination, and has agreed that:* For Rel-18 UE, for a band pair within a band combination supporting Tx switching among 3/4 bands, the switching period reported by UE for Rel-18 3/4-band Tx switching can be the same or different from the switching period for Rel-16/17 2-band switching operations.
	+ Note 1: the set of candidate values is still the same, i.e., {35 us, 140 us, 210 us}, according to the agreement in RAN4 #104e.
	+ Note 2: here the band pair is a pair of bands within which there is a switching with a switching period.
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As highlighted in yellow, RAN4 agreed that a separate Rel-18 value of a length of the switching period can be reported. Rapporteur understands RAN2 should introduce a new field for per-band-pair report of a separate length of switching period for Rel-18, i.e., by the similar way to when *uplinkTxSwitchingPeriod2T2T-r17* was introduced in Rel-17.

In addition, there is one point we should clarify: does RAN2 introduce separate UE capabilities of length of switching periods for “1Tx-2Tx” switching and “2Tx-2Tx” switching, or that of one (unified) switching period? In legacy, the lengths of switching periods for Rel-16 switching and Rel-17 switching are reported separately.

ULTxSwitchingBandPair-r16 ::= SEQUENCE {

bandIndexUL1-r16 INTEGER(1..maxSimultaneousBands),

bandIndexUL2-r16 INTEGER(1..maxSimultaneousBands),

uplinkTxSwitchingPeriod-r16 ENUMERATED {n35us, n140us, n210us},

uplinkTxSwitching-DL-Interruption-r16 BIT STRING (SIZE(1..maxSimultaneousBands)) OPTIONAL

}

ULTxSwitchingBandPair-v1700 ::= SEQUENCE {

uplinkTxSwitchingPeriod2T2T-r17 ENUMERATED {n35us, n140us, n210us} OPTIONAL

}

Now in Rel-18, the UE can report that only some bands support 2-layer MIMO UL according to following RAN2 agreement. This means that both 1Tx-2Tx switching and 2Tx-2Tx switching are possible in Rel-18 framework.

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| * For UE capability of 2-port UL transmission, RAN2 reuse the per-FS UL-MIMO UE capability (no spec change).
 |

Furthermore, RAN4 [5] informed us of their discussion on switching period applied for 1Tx-1Tx switching. It says that *the same length of switching period for 1Tx-1Tx switching and 1Tx-2Tx switching*, which implies there should be switching periods for “1Tx-2Tx switching” and “2Tx-2Tx switching”.

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| **Issue 2: 1Tx-1Tx switching case**In RAN4 #106, RAN4 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. |

**Questions**

**Question 9: Do you agree to introduce (a) new per-band-pair UE capability(ies) to report a length of a switching period for Rel-18?**

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| Company |  Yes or No  | Comments |
| OPPO | Yes |  |
| Ericsson | Yes |  |
| Huawei, HiSilicon | Yes |  |
| vivo | Yes |  |
| ZTE | Yes |  |
| CATT | Yes |  |
| Docomo | Yes | [v14\_Docomo2]For Apple’s comment, in our understanding, supported switching options are reported even if the band pair only supports 1T-1T switching (“dualUL” means that concurrent transmission on the band pair is supported while “switchedUL” means not supported). Switching period is reported for the band pair as well.[Apple2]: For the switching case A+C->B+C, I suppose the 1T-1T band pair UE report should be A+B, right? But for A+B, UE may not support normal dualUL/switchedUL. Then my original question is if UE can report A+B, whether UE should still report switchingOption for it (since I don’t think dualUL/switchingUL fits here) or the switchingOption can be absent? |
| China Telecom | Yes |  |
| Apple | Basically Yes, see comments | We want to check for those 1T-1T switching band pairs, if UE does not support normal 1T-2T/2T-2T switching band pairs, UE should still report the switching period for those 1T-1T band pairs without reporting switching option. Is this the common understanding?Or we rely on FSC (with only 1T on those two bands) to imply even UE reports a band pair with switching option, UE actually does not support 1T-2T/2T-2T switching.We prefer the former way a bit. |
| Qualcomm Incorporated | Yes |  |
| MediaTek | Yes |  |

**Question 10: Which matches to your understanding better?**

**Alt.1: RAN2 introduce one per-band-pair UE capability to report a length of a switching period.**

**Alt.2: RAN2 introduce 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).**

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| Company |  Preference  | Comments |
| OPPO | Alt1 | After check with our R4 colleague, the reply on issue-2 did not mean to have separate reporting.  |
| Ericsson | Alt1 | We think Alt1 is sufficient. Even if the values between 1Tx-2Tx and 2Tx-2Tx would be slightly different, with a single field the UE could anyway report the higher applicable value. |
| Huawei, HiSilicon | Alt2 | According to the following RAN4 agreement in R4-2214464, both of 1Tx-2Tx switching and 2Tx-2Tx switching can be supported for a Rel-18 band pair, and switching period can be same or different. Then only alt.2 is feasible to report different values for 1Tx-2Tx switching and 2Tx-2Tx switching. And only alt.2 is feasible to cover 1Tx-1Tx case which means there should be a value for 1Tx-2Tx/1Tx-1Tx switching.* 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.
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| vivo | Alt1 | If the periods of 1T2T and 2T2T are the same, then only one period to be reported is needed; otherwise, UE and gNB follows the period of 2T2T even if they are different.As a result, reporting only one period is enough. |
| ZTE | Alt 1, or up to RAN4 | We tend to agree with Ericsson that the UE can report a single value to cover both 1Tx-2Tx and 2Tx-2Tx.If we go for Alt2, then we also need to indicate 1Tx-2Tx and 2Tx-2Tx in RRC configuration, to inform the UE which switching period will be applied, if the UE supports both. This is more complex. But we are wondering whether this should be determined by RAN4?[ZTE-Update] In Rel-17, for a band pair, whether the UE can support 2Tx-2Tx switching is based on the presence/absence of 2Tx-2Tx switching period (note: the absence of 2Tx-2Tx switching period does not mean the switching period is same as 1Tx-1Tx), so if we follow the same principle for Rel-18 UL Tx switching, then Alt2 is needed. Otherwise, we need to introduce separate IE to indicate whether the UE supports 1Tx-2Tx and/or 2Tx-2Tx for Rel-18 UL Tx switching.  |
| CATT | Alt.2 with optimization | As it has been agreed by RAN1 that the value for 1Tx-2Tx switching and 2Tx-2Tx switching periods can be different, we don’t think it’s good for UE to report only one single value even if the bigger one among them is reported.Considering the big possibility that the value for 1Tx-2Tx and 2Tx-2Tx periods is the same, an optimization for signalling reduction on Alt.2 can be that the value for 2Tx-2Tx period is only reported when it is different to the value for 1Tx-2Tx period. |
| Docomo | [v16\_Docomo3]Alt.2 with comments | To be updated. I’m checking the agreement Huawei provided with RAN4 colleague.[v14\_Docomo2]Still checking. If we cannot comment in time, I will comment online or via contribution.[v16\_Docomo3]Agree with Huawei. Docomo’s understanding is, RAN4 agreed that UE can report both 1Tx-2Tx period and 2Tx-2Tx period for Rel-18 switching. We would like to refer to the endorsed CR in RAN4 (R4-230719):

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| For each band pair, the length of uplink switching period X is indicated by UE capability [uplinkTxSwitchingPeriod1T-r18] when 1Tx-1Tx switching or 1Tx-2Tx switching between the two bands in the band pair is supported and configured, or is indicated with [uplinkTxSwitchingPeriod2T-r18] when 2Tx-2Tx switching between the two bands in the band pair is supported and configured. |

We believe this is interpreted as:* RAN2 implement both UE capabilities for switching period for 1T-2T and 2T-2T, i.e., *uplinkTxSwitchingPeriod1T-r18* and *uplinkTxSwitchingPeriod2T-r18*.
* If the UE supports 1Tx-2Tx (or 1Tx-1Tx) switching on a band pair, the UE reports *uplinkTxSwitchingPeriod1T-r18.*
* If the UE supports 2Tx-2Tx switching on a band pair, the UE reports *uplinkTxSwitchingPeriod2T-r18.*
* **Note that the UE does not have to report *both*.** RAN2 can decide what to do when the UE supports both 1Tx-2Tx and 2Tx-2Tx switching

For the last bullet, there seems to be two preferences in comments.Opt.1: One (longer) period is reported and applied to both switching.Opt.2: Two separate periods are reported and applied to 1Tx-2Tx and 2Tx-2Tx, respectively.We think CATT’s suggestion enables UEs to behave both ways, thus looks like a fine compromise for us. |
| China Telecom | Alt.2 | Based on RAN4 agreement, we prefer Alt.2. |
| Apple | Alt 1 | We also think UE can report the larger value if the switching period for 1T-2T/2T-2T is different. |
| Qualcomm Incorporated | Alt.2 |  |
| MediaTek | Alt.2 | Alt.2 obviously addresses RAN4 requirement better. |

**Summary of Q9-10**

All companies answered yes to Q9, but opinions divided in Q10. Rapporteur thinks understanding on Alt.2 alters like:

Alt.2a: RAN2 introduce 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). If the UE supports both 1T-2T and 2T-2T switching for the band pair, the UE shall report both capabilities.

Alt.2b: RAN2 introduce 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). If the UE supports both 1T-2T and 2T-2T switching for the band pair, the UE can report
- both capabilities; or
- either of capabilities to be applied to both switching. (FFS on which is reported.)

RAN2 should continue discussion taking above Alts into account.

Proposal 6. Continue discussion to down-select from following alternatives.

**Alt.1: RAN2 introduce one per-band-pair UE capability to report a length of a switching period.**

**Alt.2a: RAN2 introduce 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). If the UE supports both 1T-2T and 2T-2T switching for the band pair, the UE shall report both capabilities.**

**Alt.2b: RAN2 introduce 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). If the UE supports both 1T-2T and 2T-2T switching for the band pair, the UE can report
- both capabilities.
- either of capabilities to be applied to both switching. (FFS on which is reported.)**