# **Agreements regarding multi-carrier UL Tx switching scheme**

## **RAN1#109-e**

**Conclusion**

EN-DC cases are out of scope for Rel-18 UL Tx switching

**Conclusion**

UL only cell cases are out of scope for Rel-18 UL Tx switching

**RAN1 Observation**

Four contributions ([R1-2203136](file:///C:\Users\youns\OneDrive\Documents\3GPP\RAN1%20tdocs\TSGR1_109-e\Docs\R1-2203136.zip), [R1-2204724](file:///C:\Users\youns\OneDrive\Documents\3GPP\RAN1%20tdocs\TSGR1_109-e\Docs\R1-2204724.zip), [R1-2204909](file:///C:\Users\youns\OneDrive\Documents\3GPP\RAN1%20tdocs\TSGR1_109-e\Docs\R1-2204909.zip), [R1-2205131](file:///C:\Users\youns\OneDrive\Documents\3GPP\RAN1%20tdocs\TSGR1_109-e\Docs\R1-2205131.zip)) from three companies show their evaluation results on UL Tx switching across 3 or 4 bands at RAN1#109-e meeting.

* All evaluation results show the performance gain of UL Tx switching across 4 bands compared with UL Tx switching across 2 bands, assuming TDD bands with different TDD UL/DL configurations are included in 4 bands.
  + Evaluation results in [R1-2203136](file:///C:\Users\youns\OneDrive\Documents\3GPP\RAN1%20tdocs\TSGR1_109-e\Docs\R1-2203136.zip) show the performance gain of UL Tx switching across 4 bands compared with UL Tx switching across 3 bands.
  + Evaluation results in [R1-2204724](file:///C:\Users\youns\OneDrive\Documents\3GPP\RAN1%20tdocs\TSGR1_109-e\Docs\R1-2204724.zip) show that the performance gain of UL Tx switching across 4 bands compared with UL Tx switching across 2 bands depends on achievable switching period, and the longer switching period for UL Tx switching across 4 bands compared with UL Tx switching across 2 bands leads to reduction of the performance gain. Other evaluation results did not consider the impact of longer switching period for UL Tx switching across 4 bands compared with UL Tx switching across 2 bands.
  + Evaluation results in 5131 observe that the gain highly depends on the scheduling mechanism.
  + The range of performance gains shown in four contributions varies depending on the simulation assumptions.

**Agreement**

Companies are encouraged to investigate pros and cons of following possible mechanisms for dynamic Tx carrier switching across the configured bands, and RAN1 strives for the down-selection at RAN1#110

* Alt.1: Dynamic Tx carrier switching can be across all the supported switching cases by the UE and based on the UL scheduling, i.e., via UL grant and/or RRC configuration for UL transmission
* Alt.2: NW indicates 2 bands out of the configured bands (3 or 4 bands) via DCI or MAC-CE, and dynamic Tx carrier switching between indicated bands is same as Rel-17
* Alt.3: One anchor band is selected among configured bands (3 or 4 bands), and dynamic Tx carrier switching can be performed only from the anchor band to a non-anchor band and from a non-anchor band to the anchor band
* Note: Other mechanisms are not precluded

**Agreement**

Send LS to RAN4 to ask their feedback on the potential increase of switching period and complexity in the case of UL Tx switching across 3 or 4 bands

* In the LS, observations based on the evaluation results and alternative switching mechanisms discussed in RAN1 are captured for the information to RAN4
* In the LS, RAN1 also asks RAN4 feedback on whether following assumption can be considered as baseline UE assumption/behavior even in case of the UL Tx switching across 3 or 4 bands
  + When one of the two Tx chains is triggered to switch from one band to another band, another Tx chain which is in any of bands is also not expected to be used for transmission during the switching period

LS is endorsed in R1-2205502.

**Conclusion**

If Rel-18 UL Tx switching is supported, following assumption is applied for Rel-18 UL Tx switching across up to 3 or 4 bands

* Only when the two Tx chains are linked to one NR band, the 2-ports UL transmission on the NR band is possible

**RAN1 Observation**

Following proposals to address the concern on UE/gNB complexity increase or scheduling restriction due to UL Tx switching across larger number of bands compared with Rel-16/17 are identified in contributions submitted at RAN1#109-e, and companies are encouraged to investigate pros and cons of the proposals so that one or some of them may be down-selected after the down-selection of the mechanism for dynamic Tx carrier switching across the configured bands

* UE can report the supports of only some of concurrent UL cases (combinations of 2 bands for concurrent UL transmissions)
* Switching across 0/1/2 ports is supported only for 2 configured bands out of 3 or 4 configured bands and other bands support switching across 0/1 port only
* Only switching across 0/1 port is supported across all configured bands when 3 or 4 bands are configured
* Prioritization rules between uplink carriers are specified
* No restriction on the UEs choice of MIMO capability on any of the bands/CCs involved in the UL Tx switching band combination is introduced
* After one RF state switch, the next RF state switch must occur after 14 symbols or later (FFS: which SCS is assumed for the symbol duration)
* Note: Other solutions are not precluded
* Note: each proposal assumes certain mechanism for dynamic Tx carrier switching across the configured bands, and hence some or all of the proposals may not be necessary depending on the down selection of the mechanism for dynamic Tx carrier switching across the configured bands

**Conclusion**

It is RAN1’s understanding that RAN4 should lead the discussion on UL Tx switching with multiple TAGs for both 2 bands case and more than 2 bands case

* For further discussion in RAN1 with regards to UL Tx switching with multiple TAGs, it will be discussed only if triggered by RAN4
* If it is decided to support UL Tx switching with multiple TAGs, it is RAN1's working assumption that the number of TAGs should be limited to up to 2

**RAN1 Observation**

Following possible switching configurations can be considered, and RAN1 may discuss if any of the following switching configurations need to be supported after making some progress on the discussion on the switching mechanism

* For 3 bands case
  + Switching configuration.3-1: all the 3 bands support up to 2Tx
  + Switching configuration.3-2: only 1 band out of 3 bands support up to 2Tx
  + Switching configuration.3-3: only 2 bands out of 3 bands support up to 2Tx
* For 4 bands case
  + Switching configuration.4-1: all the 4 bands support up to 2Tx
  + Switching configuration.4-2: only 1 band out of 4 bands support up to 2Tx
  + Switching configuration.4-3: only 2 bands out of 4 bands support up to 2Tx
  + Switching configuration.4-4: only 3 bands out of 4 bands support up to 2Tx
* Note: The Spec should not restrict which Tx chain is fixed or switched across certain bands.

## **RAN1#110**

**Working Assumption**

* If Rel-18 UL Tx switching is supported, following switching mechanism is considered as baseline for the Rel-18 UL Tx switching across 3 or 4 bands
  + Alt.1: Dynamic Tx carrier switching can be across all the supported switching cases by the UE and based on the UL scheduling, i.e., via dynamic grant and/or RRC configuration for UL transmission
* RAN1 will support one or more of following complexity reduction options, considering at least the potential additional preparation time, additional interruption time, and RF complexity for certain switching cases/patterns, if Rel-18 UL Tx switching is supported based on Alt.1, and companies are encouraged to investigate options with striving for down-selection at RAN1#110bis-e.
  + Option 1: UE is allowed to support only some of concurrent UL cases (band pairs)
    - FFS: at least one band pair should be supported as in Rel-17
    - FFS: for both 3 and 4 bands cases or only for 4 bands case
    - FFS: potential capability/RRC signaling
  + Option 2: UE is allowed to support 2 ports transmission only on some of bands out of configured bands for UL Tx switching
    - FFS: at least two bands should support up to 2 Tx as in Rel-17
    - FFS: for both 3 and 4 bands cases or only for 4 bands case
    - FFS: for both switched UL and dual UL cases or only for dual UL case
    - FFS: whether/how to reuse or extend existing capability/RRC signaling
  + Option 3: UE is allowed with more preparation procedure time (or interruption time) only for some specific switching cases/patterns
    - FFS: specific switching cases/patterns where more preparation procedure time (or interruption time) is necessary, e.g., switching patterns not existed in Rel-17
    - FFS: how long preparation procedure time and/or interruption time is necessary, and whether RAN4 involvement is necessary
    - FFS: whether/how to report/indicate the specific switching cases/patterns and/or value(s) of preparation procedure time (or interruption time)
    - FFS: what is the definition of preparation procedure time or interruption time, including whether interruption happens during the preparation procedure time and whether it includes switching period
    - FFS: whether/how long minimum interval between two succeeding UL Tx switching is necessary
  + Option 4: UE is allowed to support only some of band pairs for tx switching
    - FFS: at least one band pair should be supported as in Rel-17
    - FFS: for both 3 and 4 bands cases or only for 4 bands case
    - FFS: for switched UL and/or dual UL
    - FFS: potential capability/RRC signaling
  + Other options are not precluded

## **RAN1#110bis-e**

**Agreement**

If Rel-18 UL Tx switching for 3 or 4 bands with dual UL is supported, UE is allowed to support only some of band pairs for concurrent UL transmission based on UE capability

* The supported band pair for concurrent transmission requires the support of UL CA on the corresponding band pair(s) by the UE
* Details on the UE capability such as how to report the support of dual UL and the supported band pair(s) for concurrent UL transmission are further discussed
* Details on the gNB configuration/indication such as how to indicate the band pair(s) UE should expect for concurrent UL transmission are further discussed
* Note: UE is also allowed to support all band pairs for concurrent transmission, and the design of Rel-18 UL Tx switching for 3 or 4 bands with dual UL does not impose any restriction

**Agreement**

If Rel-18 UL Tx switching for 3 or 4 bands is supported, UE is allowed to support only some of band(s) for up to 2 ports UL transmission based on UE capability

* Further down-select from the following alternatives
  + Alt.1: no restriction for both switched UL and dual UL and for both 3 bands and 4 bands
  + Alt.2: at least one band should support up to 2 ports UL transmission for both switched UL and dual UL and for both 3 bands and 4 bands
  + Alt.3: at least two bands should support up to 2 ports UL transmission for both switched UL and dual UL and for both 3 bands and 4 bands
* Details on the UE capability such as whether existing per-FS UL-MIMO capability can be reused or not are further discussed
* Details on the gNB configuration/indication such as whether/how to additionally indicate 2 ports UL transmission mode for a band/cell are further discussed
* Existing MIMO mechanism for MIMO mode indication should be reused
* Note: UE is also allowed to support all bands for up to 2 ports UL transmission, and the design of Rel-18 UL Tx switching for 3 or 4 bands does not impose any restriction

**Agreement**

If Rel-18 UL Tx switching for 3 or 4 bands is supported, following is considered as baseline.

* Existing conditions where the switching period is required can be reused for Rel-18 UL Tx switching with 3 or 4 bands when only two bands are involved in a switching
* New conditions where the switching period is required should be introduced for Rel-18 UL Tx switching with 3 or 4 bands when more than two bands are involved in a switching
  + For dual UL, following new conditions are considered
    - When the UE is to transmit a 1-port or 2-port transmission on one uplink carrier on one band (1st band) and if Tx chain state at the preceding uplink transmission is 1T + 1T each on a carrier on other different bands (2nd and 3rd band)
    - When the UE is to transmit a 1-port + 1-port transmission each on one uplink carrier on different bands (1st and 2nd band) and if Tx chain state at the preceding uplink transmission is 2T on a carrier on another band (3rd band)
    - When the UE is to transmit a 1-port + 1-port transmission each on one uplink carrier on different bands (1st and 2nd band) and if Tx chain state at the preceding uplink transmission is 1T + 1T each on a carrier on one of the bands and another different band (1st or 2nd band, and 3rd band)
    - When the UE is to transmit a 1-port + 1-port transmission each on one uplink carrier on different bands (1st and 2nd band) and if Tx chain state at the preceding uplink transmission is 1T + 1T each on a carrier on other different bands (3rd and 4th band)
  + FFS for switched UL and/or for the case with complexity reduction option 1 or 2
  + FFS the same or different switch period for existing conditions and new conditions

**Conclusion**

No consensus in RAN1 on complexity reduction option 3

**Agreement**

* Consider following alternatives for UE capability reporting about the supported UL Tx switching options
  + Alt.1: report {switchedUL, dualUL, both} for each band pair in the band combination
  + Alt.2: report {switchedUL, dualUL, both} for the band combination and report supported band pair for concurrent transmission for the band combination
* Consider following alternatives for gNB configuration regarding dual UL
  + Alt.1: configure {switchedUL, dualUL} in CellGroupConfig
  + Alt.2: configure {switchedUL, dualUL} for each band pair (combination of serving cells?)
  + Alt.3: at least configuration of supported band pair (combination of serving cells) for concurrent transmission
  + Alt.4: No configuration of supported band pair (combination of serving cells) for concurrent transmission, i.e., UE just assumes as it reports

**Working Assumption**

Specify UL Tx switching schemes across up to 4 bands in Rel-18

**Working Assumption**

If Rel-18 UL Tx switching for 3 or 4 bands is supported, both Switched UL and Dual UL are supported

**Agreement**

Confirm the following working assumption made at the RAN1#110 meeting.

**Working Assumption**

If Rel-18 UL Tx switching is supported, following switching mechanism is considered as baseline for the Rel-18 UL Tx switching across 3 or 4 bands

* Alt.1: Dynamic Tx carrier switching can be across all the supported switching cases by the UE and based on the UL scheduling, i.e., via dynamic grant and/or RRC configuration for UL transmission

**Working Assumption**

At least for dual UL, reuse existing RRC parameter {oneT, twoT} via uplinkTxSwitching-DualUL-TxState to solve the issue on ambiguous switching state at least for following cases

* Case#1 of the issue: two Tx chains are currently associated with band A, and next transmission is 1 port transmission on band B, but there are multiple possible switching cases where 1P on band B is supported
  + if twoT is indicated, both of two Tx chains are switched to band B
  + if oneT is indicated, one Tx chain is switched to band B while another Tx chain remains on band A
* Case#2 of the issue: two Tx chains are currently associated with band A and B, and next transmission is 1 port transmission on band C, but there are multiple possible switching cases where 1P on band C is supported
  + if twoT is indicated, both of two Tx chains are switched to band C
  + if oneT is indicated, one Tx chain is switched to band C while how to determine the associated band for another Tx chain is FFS
    - Alt.1: based on gNB’s configuration/indication e.g., new RRC parameter
    - Alt.2: based on predefined rule
    - Other alternative is not precluded
* FFS for other potential cases

**Agreement**

Ask RAN2 to consider following alternatives for UE capability reporting about the supported UL Tx switching options

* + Alt.1: report {switchedUL, dualUL, both} for each band pair in the band combination
  + Alt.2: report {switchedUL, dualUL, both} for the band combination and report supported band pair for concurrent transmission for the band combination
    - Note：If there is no report on the supported band pair(s) for concurrent transmission while the UE reports “dualUL” or “both” for the band combination, gNB may assume that the UE supports concurrent transmission on all the band pairs within the band combination
  + Alt.3: report {dualUL} for each band pair in the band combination
    - Note: Within the band combination, the UE shall be capable of being operated in switched UL mode for all band pairs

**Agreement**

Ask RAN2 to consider following alternatives and specify gNB configuration

* + Alt.1: configure {switchedUL, dualUL} for all serving cells (i.e., for the band combination)
  + Alt.2: configure {switchedUL, dualUL} for combination(s) of serving cells (i.e., for each band pair in the band combination)
  + Alt.3: configure {switchedUL, dualUL} for all serving cells (i.e., for the band combination), and configure combination(s) of serving cells (i.e., as supported serving cell pair(s) for each band pair in the band combination) for concurrent transmission

**Working assumption**

Study the following alternatives for the minimum separation time between two UL Tx switchings for Rel-18 UL Tx switching schemes across up to 3 or 4 bands, and decide in RAN1#111 whether/which of the following alternatives is needed

* Alt.1: define 14 symbols based on a SCS (FFS on SCS) as minimum separation time between two UL Tx switchings
* Alt.2: define that no more than one uplink Tx switching within a reference slot based on a SCS (FFS on SCS)
* Alt.3: define X slots as minimum separation time between two UL Tx switchings where 3 bands are involved in total, and define Y slots as minimum separation time between two UL Tx switchings where 4 bands are involved in total, where X and/or Y is no less than 1 (FFS on X,Y, FFS reference SCS for the slots in case of multiple SCSs across carriers or expressed in unit of micro second)
* Alt.4: report the minimum separation time for different switching cases
* Other alternative is not precluded
* FFS: Applicable cases for the restriction
* Note: Companies are encouraged to provide detailed numbers of minimum separation time

**Agreement**

Consider following alternatives on the supported switching cases (Tx chain states) for each scenario

* Scenario#1: For switched UL, if UE supports up to 2 ports UL transmission on all the bands in the band combination,
  + Alt.1-1: only switching cases (Tx chain states) with 2T are assumed
    - In case of 3 bands, 3 switching cases ({2T,0T,0T}, {0T,2T,0T}, {0T,0T,2T}) are assumed
    - In case of 4 bands, 4 switching cases ({2T,0T,0T,0T}, {0T,2T,0T,0T}, {0T,0T,2T,0T}, {0T,0T,0T,2T}) are assumed
  + Alt.1-2: switching cases (Tx chain states) with 1T-1T can also be assumed
    - FFS: detailed switching cases to be assumed
* Scenario#2: For switched UL, if UE supports up to 2 ports UL transmission only on some of the bands,
  + Alt.2-1: for the band where 2 ports UL transmission is not supported, switching cases (Tx chain states) with 1T-1T can be assumed
    - FFS: detailed switching cases to be assumed with different number of bands supporting up to 2 ports UL transmission
  + Alt.2-2: only switching cases (Tx chain states) with 2T are assumed
    - Assumed switching cases are same as Scenario#1
  + Alt.2-3: switching cases (Tx chain states) with 1T-1T can also be assumed
    - FFS: detailed switching cases to be assumed
* FFS: Scenario#3: For dual UL, if UE does not support concurrent transmission on specific band pair(s) and supports up to 2 ports UL transmission on all the bands in the band combination,
  + Alt.3-1: corresponding switching case(s) with 1T-1T for the band pair(s) are not assumed
    - FFS: if UE does not support concurrent transmission on specific band pair(s) and supports up to 2 ports UL transmission only on some of the bands
  + Alt.3-2: corresponding switching case(s) with 1T-1T for the band pair(s) are assumed
    - Assumed switching cases are same as the case where UE supports dual UL for all band pairs in the band combination

**Agreement**

LS on UE capability and gNB configuration for UL Tx switching across 3 or 4 bands in Rel-18 is endorsed. Final LS in R1-2210724.

## **RAN1#111**

**Agreement**

For switched UL, if UE supports up to 2 ports UL transmission on all the bands in the band combination, only switching cases (Tx chain states) with 2T are assumed

* Conclusion: In case of 3 bands, 3 switching cases ({2T,0T,0T}, {0T,2T,0T}, {0T,0T,2T}) are assumed
* Conclusion: In case of 4 bands, 4 switching cases ({2T,0T,0T,0T}, {0T,2T,0T,0T}, {0T,0T,2T,0T}, {0T,0T,0T,2T}) are assumed
* Based on the assumption, the switching gap is required for every UL transmission with changing transmitting band from preceding transmission in this scenario

**Agreement**

For switched UL, if UE supports up to 2 ports UL transmission only on some of the bands in the band combination, only switching cases (Tx chain states) with 2T are assumed

* Based on the assumption, the switching gap is required for every UL transmission with changing transmitting band from preceding transmission in this scenario

**Agreement**

For dual UL, if a UE does not support concurrent transmission on specific band pair(s) and supports up to 2 ports UL transmission on all the bands in the band combination, corresponding switching case(s) with 1T-1T for the band pair(s) where concurrent transmission is not supported are not assumed

**Agreement**

For dual UL, if UE supports concurrent transmission on all band pairs and supports up to 2 ports UL transmission on all the bands in the band combination, all possible switching cases with 1T-1T and 2T are assumed

* In case of 3 bands, 6 switching cases ({2T,0T,0T}, {0T,2T,0T}, {0T,0T,2T}, {1T, 1T, 0T}, {1T, 0T, 1T}, {0T, 1T, 1T}) are assumed
* In case of 4 bands, 10 switching cases ({2T,0T,0T,0T}, {0T,2T,0T,0T}, {0T,0T,2T,0T}, {0T,0T,0T,2T}, {1T,1T,0T,0T}, {1T,0T,1T,0T}, {1T,0T,0T,1T}, {0T,1T,1T,0T}, {0T,1T,0T,1T}, {0T,0T,1T,1T}) are assumed

**Agreement**

For dual UL, if UE supports up to 2 ports UL transmission only on some of the bands in the band combination, corresponding switching case(s) with 2T for the band where up to 2 ports transmission is not supported are assumed

* If the UE does not support concurrent transmission on specific band pair(s) in the band combination, corresponding switching case(s) with 1T-1T for the band pair(s) where concurrent transmission is not supported are not assumed

**Agreement**

Following new conditions are applicable to dual UL only (i.e., not applicable to switched UL)

* When the UE is to transmit a 1-port or 2-port transmission on one uplink carrier on one band (1st band) and if Tx chain state at the preceding uplink transmission is 1T + 1T each on a carrier on other different bands (2nd and 3rd band)
* When the UE is to transmit a 1-port + 1-port transmission each on one uplink carrier on different bands (1st and 2nd band) and if Tx chain state at the preceding uplink transmission is 2T on a carrier on another band (3rd band)
* When the UE is to transmit a 1-port + 1-port transmission each on one uplink carrier on different bands (1st and 2nd band) and if Tx chain state at the preceding uplink transmission is 1T + 1T each on a carrier on one of the bands and another different band (1st or 2nd band, and 3rd band)
* When the UE is to transmit a 1-port + 1-port transmission each on one uplink carrier on different bands (1st and 2nd band) and if Tx chain state at the preceding uplink transmission is 1T + 1T each on a carrier on other different bands (3rd and 4th band)

**Agreement**

Following working assumption is confirmed with updates.

**Working Assumption**

~~At least~~ for dual UL, reuse existing RRC parameter {oneT, twoT} via uplinkTxSwitching-DualUL-TxState to solve the issue on ambiguous switching state at least for following cases

* Case#1 of the issue: two Tx chains are currently associated with band A, and next transmission is 1 port transmission on band B, but there are multiple possible switching cases where 1P on band B is supported
  + if twoT is indicated, both of two Tx chains are switched to band B
  + if oneT is indicated, one Tx chain is switched to band B while another Tx chain remains on band A
* Case#2 of the issue: two Tx chains are currently associated with band A and B, and next transmission is 1 port transmission on band C, but there are multiple possible switching cases where 1P on band C is supported
  + if twoT is indicated, both of two Tx chains are switched to band C
  + if oneT is indicated, one Tx chain is switched to band C while how to determine the associated band for another Tx chain is ~~FFS~~
    - ~~Alt.1:~~ based on ~~gNB’s configuration/indication e.g.,~~ new RRC parameter
    - ~~Alt.2: based on predefined rule~~
    - ~~Other alternative is not precluded~~
* ~~FFS for other potential cases~~

**Agreement**

In Case#2 where two Tx chains are currently associated with band A and B, and next transmission is 1 port transmission on band C, if oneT is indicated via uplinkTxSwitching-DualUL-TxState, one Tx chain is switched to band C and associated band for another Tx chain is determined by new RRC parameter which is down-selected from following alternatives.

* An associated band is configured for each band so that another Tx chain is associated with the configured band (as associated band for the transmitting band)
  + E.g., associated band for each transmitting band is configured as {B for A}, {A for B}, {A for C} and {C for D}.
    - When 1 port transmission on band C is scheduled and Tx chains are currently associated with band A and B, Tx chain associated with band B is switched to band C while another Tx chain associated with band A remains unchanged (because band A is associated band for band C)
    - When 1 port transmission on band D is scheduled and Tx chains are currently associated with band A and B, Tx chain associated with band A (or B) is switched to band D while another Tx chain associated with band B (or A) is switched to band C (because band C is associated band for band D)

If there is one band where concurrent transmission with any other band is not supported, NW does not configure an associated band for the band. In such case, even if oneT is configured, UE performs switching as twoT is configured when 1 port transmission on the band is scheduled

**Agreement**

There is no restriction on number of bands supporting up to 2 ports UL transmission for both switched UL and dual UL and for both 3 bands and 4 bands.

* It is up to UE capability to support 2 ports UL transmission on none/some/all of the 3 or 4 bands
* Note: UE with only 1 Tx chain is not expected to perform UL Tx switching (no spec impact)

**Agreement**

Confirm the following working assumption.

**Working Assumption**

Specify UL Tx switching schemes across up to 4 bands in Rel-18

**Agreement**

Following restrictions are applied for Rel-18 UL Tx switching across 3 or 4 bands.

* The UE does not expect to perform more than one uplink switching within a reference slot based on µUL = max(µUL, 1, µUL, 2, µUL, 3) in case of 3 bands, µUL = max(µUL, 1, µUL, 2, µUL, 3, µUL, 4) in case of 4 bands, where µUL, 1, µUL, 2, µUL, 3, µUL, 4 are SCSs of active UL bandwidth parts of the bands in the band combination
  + If there are two consecutive intra-band carriers in one band, µUL, 1 = max(µUL, 1-1, µUL, 1-2), where µUL, 1-1 and µUL, 1-2 are SCSs of active UL bandwidth parts of the carriers in the band
* (working assumption) If two uplink switching are triggered and result in UL transmissions on more than 2 bands within any two consecutive reference slots, then the time duration between the end of all transmission(s) prior to the first uplink switching and the start of all transmission(s) after the second uplink switching within the two reference slots is expected to be not less than a minimum separation time
  + The minimum separation time is a sum of X us and the switching gap required for the second uplink switching.
  + X us is subject to UE capability with a value set of {0us, 500us}

## **RAN1#112**

**Agreement**

Confirm the working assumption with following updates

(working assumption) If two uplink switching are triggered and UL transmissions involved in the two uplink switching are on more than 2 bands within any two consecutive reference slots, then the time duration between the start of all transmission(s) after the first uplink switching and the start of all transmission(s) after the second uplink switching within the two reference slots is expected to be not less than a minimum separation time

* The minimum separation time is a maximum of X us and the switching gap required for the second uplink switching.
* X us is subject to UE capability with a value set of {0us, 500us}

**Agreement**

Alt.5: gNB configures priorities to each carrier/band.

* The gNB configures priority for each band. The UE determines the switching period location on either switching-from band(s) or switching-to band(s) that is involved in the UL Tx switching and is not with the highest priority band.

## **RAN1#112bis-e**

Agreement

[**R1-2304238**](file:///C:\MyMeetings\TSGR1_112b-e\Docs\R1-2304238.zip) captures the higher layers parameters for the following Rel-18 work items and TEI that are considered stable from RAN1 perspective:

* NR network-controlled repeaters (NR\_netcon\_repeater-Core)
* Enhancement of NR Dynamic Spectrum Sharing (NR\_DSS\_enh)
* Multi-carrier enhancements for NR (NR\_NC\_enh-Core)
* BandWidth Part operation without restriction in NR (BWP\_wor)
* 1-symbol PRS (TEI18)

Note: The updates in the list as compared to the already communicated higher layer parameters to RAN2/RAN3 are highlighted in blue.

Note: [R1-2304221](file:///C:\MyMeetings\TSGR1_112b-e\Docs\R1-2304221.zip)captures all the discussed higher layers parameters including the stable and unstable ones.

Agreement

* Introduce FG 49-X as follows

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 49. NR\_MC\_enh | 49-X | Supported switching option for each band pair in the band combination for UL Tx switching across more than 2 bands | Indicate supported switching option for each band pair in the band combination for UL Tx switching across more than 2 bands   * Candidate value set is {switchedUL, dualUL, both} |  | Yes |  | [UL Tx switching across more than 2 bands cannot be supported for the band pair in the band combination] | [Per band pair per band combination, details up to RAN2] | [N/A] | [N/A] | [N/A] | This FG is based on the following agreements. RAN1 will not discuss the detail of this FG and the detail is up to RAN2  [Agreement  Ask RAN2 to consider following alternatives for UE capability reporting about the supported UL Tx switching options   * Alt.1: report {switchedUL, dualUL, both} for each band pair in the band combination]   [Agreement in RAN2#121  For UE capability of switching options, introduce a per-band-pair UE capability to report supported switching options for Rel-18 UL Tx switching.] | Optional with capability signaling |

Agreement:

Introduce FG 49-Y as follows

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 49. NR\_MC\_enh | 49-Y | Minimum separation time for two uplink switching on more than 2 bands within any two consecutive reference slots | If two uplink switchings are triggered and UL transmissions involved in the two uplink switchings are on more than 2 bands within any two consecutive reference slots, then the time duration between the start of all transmission(s) after the first uplink switching and the start of all transmission(s) after the second uplink switching within the two reference slots is expected to be not less than a minimum separation time   * The minimum separation time is a maximum of X us and the switching gap required for the second uplink switching, and X us is reported with a candidate value set of {[0us], 500us} * The reported value X is applied to both one TAG case and two-TAG case (if UE supports two-TAG case)   FFS: Note: If the UE reports [0us], the minimum separation time is not applied | 49-X | Yes |  | [two uplink switching cannot be triggered in two consecutive reference slots for UL transmissions on more than 2 bands] | Per BC | N/A | N/A | N/A |  | Optional with capability signaling |

## **RAN1#113**

**Agreement**

* FG 49-X is updated as follows

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 49. NR\_MC\_enh | 49-X | Supported switching option for each band pair in the band combination for UL Tx switching across more than 2 bands | Indicate supported switching option for each band pair in the band combination for UL Tx switching across more than 2 bands  Candidate value set is {switchedUL, dualUL, both} |  | Yes |  | ~~[~~UL Tx switching across more than 2 bands cannot be supported for the band pair in the band combination~~]~~ | ~~[~~Per band pair per band combination, details up to RAN2~~]~~ | ~~[~~N/A~~]~~ | ~~[~~N/A~~]~~ | ~~[~~N/A~~]~~ | This FG is based on the following agreements. RAN1 will not discuss the detail of this FG and the detail is up to RAN2  ~~[~~Agreement  Ask RAN2 to consider following alternatives for UE capability reporting about the supported UL Tx switching options   * Alt.1: report {switchedUL, dualUL, both} for each band pair in the band combination~~]~~   ~~[~~Agreement in RAN2#121  For UE capability of switching options, introduce a per-band-pair UE capability to report supported switching options for Rel-18 UL Tx switching.~~]~~ | Optional with capability signaling |

**Agreement**

* If the UE reports 0us in FG 49-Y, the minimum separation time is not applied
  + FFS the consequence if UE does not report FG 49-Y

Ad-hoc chair’s note

* RAN1 does not send reply LS in R1-2304333 from RAN2 in RAN1#113

**Agreement**

The following is agreed as response to RAN4 LS in R1-2304313.

* When gNB does not provide sufficient time between the end of the UL transmission on the switch-from carrier and the start of the UL transmission on the switch-to carrier, and the switching period is located at the switch-to carrier according to the RRC signalling *uplinkTxSwitchingPeriodLocation*, UE may omit uplink transmission on certain symbol(s) on the switch-to carrier. From RAN1 perspective, T0 is the starting time of uplink transmission from network scheduling perspective.

Final LS is in R1-2306211.