**3GPP TSG-RAN WG4 Meeting # 98-e R4-2103004**

**Electronic Meeting, 25 Jan. – 5 Feb. 2021**

**Agenda item:** 15.1

**Source:** Moderator (Samsung)

**Title:** Email discussion summary for [98e][156] NR\_reply\_LS\_Part\_3

**Document for:** Information

# Introduction

*Briefly introduce background, the scope of this email discussion and provide some guidelines for email discussion if necessary.*

RAN4 has received an LS from RAN1 [R1-2009807] on beam switching gaps for multi-TRP UL transmission, in which RAN1 agreements and working assumptions on multi-TRP transmission/repetition schemes for both PUCCH and PUSCH are shared, with questions to RAN4 as follows:

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| While the questions below are formulated based on different beams in the context of FR2, RAN1 is also interested in the answers for FR1 in the case of PUCCH/PUSCH repetitions follow different transmission power control.  RAN1 seeks few answers from RAN4 to proceed further with the working assumptions based on existing RAN1 agreements,  **Question 1**: What are the ranges of the transient period(s) between two PUCCH/PUSCH TDMed repetitions (with different UL beams)?  **Question 2:** In RAN4 perspective, are there additional considerations that RAN1 shall account for a switching gap (blanked symbol(s)) between two PUCCH/PUSCH TDMed repetitions (with different UL beams)?  **Question 3:** For different beam mapping principles (i.e. cyclical and sequential mapping patterns), is there any additional complexity that RAN4 foresees when applying cyclical beam mapping vs sequential beam mapping?  **Question 4:** In particular to multi-TRP intra-slot beam hopping (Scheme 2), can RAN1 assume the same requirement as RB hopping with respect to transient period in current RAN4 requirements, if the two hops have different UL beams in addition to different RBs? |

*List of candidate target of email discussion for 1st round and 2nd round*

* 1st round: TBA
* 2nd round: TBA

This email thread is used to discussion above questions and response the RAN1 LS, with the following plan to organize the discussion:

* 1st round: Discussion on issues based on companies’ contribution input.
* 2nd round: Achieve agreements on the reply LS to RAN1

# Topic #1: Beam switching gaps for Multi-TRP UL transmission

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2101017 | Apple | ***Observation #1:*** *The transient time for SRS switching in FR1 could be reused with transmission switching with different power levels and from antenna ports.*  ***Observation #2:*** *The transient time in FR2 could be 5us with transmission with different power levels.*  ***Observation #3:*** *The time for TX beam switch ranges from few symbols up to 1 slot if the spatial filter to transmit the beam is known*.  ***Observation #4:*** *The time for TX beam switch would further include the additional time for beam refinement on top of transient period if the spatial filter to transmit the beam is unknown*.  ***Observation #5:*** *The beam switching delay might need to consider different UL TX timing for transmissions to multi-TRP.*  **Question 1**: What are the ranges of the transient period(s) between two PUCCH/PUSCH TDMed repetitions (with different UL beams)?  **[RAN4]** The transient period between two PUCCH/PUSCH TDMed repetitions should account for TX power change, TX beam change and possibly TX timing change. The TX timing change is not including in the transient period below.  In FR1, the transient period needs to account for TX power change and ranges from 10us to 15us depending on whether the switch from one transmission to the next is from the same antenna port or different antenna ports.  In FR2, the transient period shall account for TX power change, TX beam change. The transient due to TX power change is 5us in FR2. The TX beam change should also consider if the beams are known (Spatial filter for transmission is known and not outdated). In case the TX beam is unknown, the transient time needs to account for beam refinement time. In addition, the TX beam change also need to consider inter-panel beam switch. Accounting for inter-panel TDMed transmissions, the transient period could be few symbols up to 1 slot, assuming the beams are known.  It is not practical to assume that UE would keep both panels active continuously and hence need to consider panel activation, de-activation time and the associated interruption on ongoing transmission on all CCs. The length of the interruption can be a few symbols up to 1 slot.  **Question 2:** In RAN4 perspective, are there additional considerations that RAN1 shall account for a switching gap (blanked symbol(s)) between two PUCCH/PUSCH TDMed repetitions (with different UL beams)?  **[RAN4]** In all cases, when the switching delay is longer than a threshold, e.g. CP length, a switching gap can be considered. In certain cases, when the switching delay is more than 1/3rd the symbol time in the operating SCS, a switching gap should be considered.  **Question 3:** For different beam mapping principles (i.e. cyclical and sequential mapping patterns), is there any additional complexity that RAN4 foresees when applying cyclical beam mapping vs sequential beam mapping?  **[RAN4]** Comparing the cyclic and sequential mapping, cyclic mapping has more frequent switches. Cyclic mapping would result in more power consumption at the UE in addition to more switching gaps. Cyclic mapping also increases the interruption to other ongoing transmissions with more frequent activation and de-activation of panels.  **Question 4:** In particular to multi-TRP intra-slot beam hopping (Scheme 2), can RAN1 assume the same requirement as RB hopping with respect to transient period in current RAN4 requirements, if the two hops have different UL beams in addition to different RBs?  **[RAN4]** The current RAN4 requirements for transient times are applicable when RB hopping, or power change is applied. In case of RB hopping with different UL beams, we need to consider additional time due to power change and TX beam switching.  In addition, RAN4 also would like to clarify the following with RAN1:  Responses from RAN4 are based on the assumption that the same UL timing is used for transmission of both UL beams. Assuming that the UL beams are associated with different DL-RS from different TRP, there could be different DL timing correction for each. What is the TX timing assumption for different UL beam transmissions? |
| R4-2101157 | MediaTek | **Observation 1: UL Tx beam switching is highly likely to be done together with UL transmit power change due to different path losses observed from 2 TRPs.**  **Observation 2: The transition time of beam hopping is much smaller than the CP**  **Proposal 1: RAN4 to reply a single value of transient period to RAN1, considering UL Tx beam, RB allocation and UL transmit power are changed at the same time.**  **Proposal 2: The transition time for multi-TRP PUCCH/PUSCH transmission shall mainly consider the frequency hopping and power change.**  **Proposal 3: The transition time for beam hopping, frequency hopping and power change can reuse the same transition time defined in TS38.101-1 and TS38.101-2, i.e., 15us and 5us for FR1 and FR2, respectively.**  **Question 1**: What are the ranges of the transient period(s) between two PUCCH/PUSCH TDMed repetitions (with different UL beams)?  **Answer**: UE UL beam switch between two PUCCH/PUSCH TDMed repetitions is expected to be conducted together with UL transmit power change. Therefore, 15us and 5us are required for FR1 and FR2, respectively.  **Question 2:** In RAN4 perspective, are there additional considerations that RAN1 shall account for a switching gap (blanked symbol(s)) between two PUCCH/PUSCH TDMed repetitions (with different UL beams)?  **Answer**: When the transient period is larger than CP, the switching gap is needed to avoid the performance degradation.  **Question 3:** For different beam mapping principles (i.e. cyclical and sequential mapping patterns), is there any additional complexity that RAN4 foresees when applying cyclical beam mapping vs sequential beam mapping?  **Answer**: RAN4 does not see any additional complexity.  **Question 4:** In particular to multi-TRP intra-slot beam hopping (Scheme 2), can RAN1 assume the same requirement as RB hopping with respect to transient period in current RAN4 requirements, if the two hops have different UL beams in addition to different RBs?  **Answer**: Yes. |
| R4-2102389  R4-2102390 | Huawei, HiSilicon | **Question 1**: What are the ranges of the transient period(s) between two PUCCH/PUSCH TDMed repetitions (with different UL beams)?  **Answer 1**: For the case that different beams switched in the same panel, the switching could be completed in CP for 120kHz SCS for FR2 UE, thus transient period of 5us as defined in the RAN4 spec plays the main role between two PUCCH/PUSCH TDMed repetitions.  For the case that different beams switched cross panels, RAN4 once discussed similar beam switching issue in Rel-15. The switching time is reported as UE capability, where 224 and 336 symbol length are used for cross panel switching. In this case, the trainset period would be determined by the beam switching time.  **Question 2**: In RAN4 perspective, are there additional considerations that RAN1 shall account for a switching gap (blanked symbol(s)) between two PUCCH/PUSCH TDMed repetitions (with different UL beams)?  **Answer 2**: As 5us transient period defined in RAN4 specification occupies larger part of a symbol for 120kHz SCS, a blanked symbol is considered in the time mask requirement for FR2 UE. However, whether a switching gap should be defined from performance or PHY design perspective, RAN4 thinks that it should be determined by RAN1.  **Question 3**: For different beam mapping principles (i.e. cyclical and sequential mapping patterns), is there any additional complexity that RAN4 foresees when applying cyclical beam mapping vs sequential beam mapping?  **Answer 3**: From the definition, beam switching for cyclical mapping could occur more frequently than that of sequential beam mapping. However, from implementation perspective, no big difference or additional complexity is foreseen for the UE by RAN4.  **Question 4**: In particular to multi-TRP intra-slot beam hopping (Scheme 2), can RAN1 assume the same requirement as RB hopping with respect to transient period in current RAN4 requirements, if the two hops have different UL beams in addition to different RBs?  **Answer 4**: For RB hopping, transient period is defined as 5us for FR2 UE. Similar to Q1, beam hopping could be happened in the same panel or between two panels. Transient period due to RB hopping is the main factor for the same panel case, while for cross panels case, switching period is mainly determined by beam switching, which is 224 or 336 symbol length according to UE capability based on RAN4 agreement.  Regarding to the question for FR1 in the case of PUCCH/PUSCH repetitions follow different transmission power control, since beam switching is less relevant to FR1 than that for FR2, transient period due to power change defined as 10us in RAN4 specification can be considered by RAN1. |
| R4-2102710 | Vivo | **Observation 1**: RAN1’s main interest is in possible impact of the beam related behaviour to transient period and gaps etc.  **Observation 2**: There are many situations that would need to be considered in RAN1’s provided conditions.  **Observation 3**: Between continuous ON-power transmissions, RAN4 have defined transient period allowed for the following two cases: power change or RB hopping is applied.  **Observation 4**: For the minimum requirement number, generally 10us for FR1 and 5 us for FR2.  **Observation 5:** Only in the case of the highest SCS and transient period is required on both sides of the symbol, a one symbol gap is defined in RAN4 requirements. (As in Figure 6.3.3.9-3 in TS38.101-1 and Figure 6.3.3.9-3 in TS38.101-2)  **Observation 6**: The beam switching delay for PUCCH & PUSCH beam sweeping is not related to PDCCH/MAC\_CE/RRC decoding, and it is not related to whether the status is known or unknown.  **Observation 7**: Indicating change to the spatial relation info of the SRSs that provide beam sweeping information of PUSCH & PUCCH transmission is another issue, and the requirements are already discussed in R16 RRM enhancement.  ***Question 1****: What are the ranges of the transient period(s) between two PUCCH/PUSCH TDMed repetitions (with different UL beams)?*  For two PUCCH/PUSCH TDMed repetitions (with different UL beams), according to the previous RAN1 background, they may “follow different transmission power control”. It means there may be a power change. In case there is a power change, the current transient period minimum requirements (10us for FR1 and 5us for FR2) should apply. In case no such power change, this transient period need not be considered.  Although the transient period is defined in R15 considering beam sweeping within a panel, companies see it can also apply to the case of beam sweeping between panels. Therefore, the same requirements are assumed.  **Question 2:** In RAN4 perspective, are there additional considerations that RAN1 shall account for a switching gap (blanked symbol(s)) between two PUCCH/PUSCH TDMed repetitions (with different UL beams)?  Currently RAN4 only consider a one symbol gap in the case of the highest SCS and transient period is required on both sides of the symbol. For other cases, blanked symbol is not defined.  **Question 3:** For different beam mapping principles (i.e. cyclical and sequential mapping patterns), is there any additional complexity that RAN4 foresees when applying cyclical beam mapping vs sequential beam mapping?  As in answer for question 2, RAN4 only consider a one symbol gap in the case of the highest SCS and transient period is required on both sides of the symbol. For other cases, blanked symbol is not defined. Therefore, there is no additional complexity.  **Question 4:** In particular to multi-TRP intra-slot beam hopping (Scheme 2), can RAN1 assume the same requirement as RB hopping with respect to transient period in current RAN4 requirements, if the two hops have different UL beams in addition to different RBs?  As long as RB hopping and/or power changes applies, RAN4 requirement is the same. |

## Open issues summary

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 1-1: transient period between two PUCCH/PUSCH TDMed repetitions

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 1-1-1: ranges of the transient period(s) between two PUCCH/PUSCH TDMed repetitions with different UL beams switched in the same panel**

* Proposals:
  + Option 1: 5us
  + Option 2: 5us if the beams are known; In case the TX beam is unknown, the transient time needs to account for beam refinement time
* Recommended WF
  + TBA.

**Issue 1-1-2: ranges of the transient period(s) between two PUCCH/PUSCH TDMed repetitions with different UL beams switched cross panels**

* Proposals:
  + Option 1: 5us
  + Option 2: the transient period would be determined by the beam switching time which is reported as UE capability, where 224 and 336 symbol length are used for cross panel switching
  + Option 3: ranges from few symbols up to 1 slot if the spatial filter to transmit the beam is known. Additional beam refinement time need to be considered if the beam is unknown. Panel activation, de-activation time and the associated interruption on ongoing transmission on all CCs shall also be considered which can be a few symbols up to 1 slot.
* Recommended WF
  + TBA

**Issue 1-1-3: the ranges of the transient period(s) between two PUCCH/PUSCH TDMed repetitions for FR1 UE**

* Proposals:
  + Option 1: reply RAN1 with a single value 10us
  + Option 2: reply RAN1 with a single value 15us
  + Option 3: ranges from 10us to 15us depending on whether the switch from one transmission to the next is from the same antenna port or different antenna ports
* Recommended WF
  + TBA

### Sub-topic 1-2: blanked symbol(s) consideration for a switching gap

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 1-2-1: whether there are additional RAN4 considerations that RAN1 shall account for a switching gap (blanked symbol(s)) between two PUCCH/PUSCH TDMed repetitions (with different UL beams)**

* Proposals:
  + Option 1: In all cases, when the switching delay is longer than a threshold, e.g. CP length, a switching gap can be considered. In certain cases, when the switching delay is more than 1/3rd the symbol time in the operating SCS, a switching gap should be considered.
  + Option 2: When the transient period is larger than CP, the switching gap is needed to avoid the performance degradation
  + Option 3: Whether a switching gap should be defined from performance or PHY design perspective, RAN4 thinks that it should be determined by RAN1 though RAN4 defines minimum time mask requirement with a blanked symbol
  + Option 4: Currently RAN4 only consider a one symbol gap in the case of the highest SCS and transient period is required on both sides of the symbol. For other cases, blanked symbol is not defined.
* Recommended WF
  + TBA.

### Sub-topic 1-3: different beam mapping patterns

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 1-3-1: whether RAN4 foresees any additional complexity when applying cyclical beam mapping vs sequential beam mapping?**

* Proposals:
  + Option 1: RAN4 does not see any additional complexity.
  + Option 2: Cyclic mapping would result in more power consumption at the UE in addition to more switching gaps. Cyclic mapping also increases the interruption to other ongoing transmissions with more frequent activation and de-activation of panels.
  + Option 3: Power consumption could be slightly different, however, from implementation perspective, no big difference or additional complexity is foreseen for the UE by RAN4.
* Recommended WF
  + TBA.

### Sub-topic 1-4: multi-TRP intra-slot beam hopping (Scheme 2)

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 1-4-1: whether RAN1 can assume the same requirement as RB hopping with respect to transient period in current RAN4 requirements, if the two hops have different UL beams in addition to different RBs**

* Proposals:
  + Option 1: Yes
  + Option 2: The current RAN4 requirements for transient times are applicable when RB hopping, or power change is applied. In case of RB hopping with different UL beams, we need to consider additional time due to power change and TX beam switching.
  + Option 3: beam hopping could be happened in the same panel or between two panels. Transient period due to RB hopping is the main factor for the same panel case, while for cross panels case, switching period is mainly determined by beam switching, which is 224 or 336 symbol length according to UE capability based on RAN4 agreement.
* Recommended WF
  + TBA

### Sub-topic 1-5: TX timing aspect

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 1-5-1: whether different TX timing is considered for different UL beam transmissions**

* Background: Responses from RAN4 are based on the assumption that the same UL timing is used for transmission of both UL beams. Assuming that the UL beams are associated with different DL-RS from different TRP, there could be different DL timing correction for each.
* Proposals:
  + Option 1: ask RAN1 what the TX timing assumption is for different UL beam transmissions.
  + Option 2: tell RAN1 the same UL timing is assumed for different UL beam transmissions in current RAN4 requirements.
* Recommended WF
  + TBA.

## Companies views’ collection for 1st round

### Open issues

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| **Company** | **Comments** |
| MediaTek | Issue 1-1-1: both options are fine to us. In our understanding, RAN1 does not care known or unknown Tx beam. Some clarification is needed on whether this additional know/unknown information can help RAN1 progress.  Issue 1-1-2: support option 2. In our contribution, we do not cover the case with panel switch. If beam switching cross panel is considered, UE needs more time to warm up.  Issue 1-1-3: support option3. The transient period is depending on same or different antenna ports. It is fine to us to provide RAN1 the detail. It is up to RAN1 to select which value for their scenarios.  Issue 1-2-1: support option2. In our understanding, if the transient time is covered by CP, then it should be ok without switching gap.  Issue 1-3-1: support option 2 and 3. We agree the power consumption may be different when cyclic mapping is applied, although it is not clear at this moment about how much the difference in power consumption is.  Issue 1-4-1: For the transient time of RB hopping in the same panel, the existing transient time could be reused. For the different panel, the transient time shall follow the requirement of the beam hopping.  Issue 1-5-1: According to the conclusion of uplink spatial relation switching in RRM section, UE is not provided with time of a timing tracking. As a consequence, timing accuracy requirement for uplink spatial relation switching is not defined. We believe it is completely up to UE implementation. |
| Qualcomm | Sub topic 1-1:  **Issue 1-1-1: ranges of the transient period(s) between two PUCCH/PUSCH TDMed repetitions with different UL beams switched in the same panel**   * + Option 1: 5us for FR2   **Issue 1-1-2: ranges of the transient period(s) between two PUCCH/PUSCH TDMed repetitions with different UL beams switched cross panels**   * + Option 1: 5us for FR2. In this scenario the UE knows which beams it is using to do switching. It also knows whether these beams are located on different panels. If switching across panels is required, then the UE would turn on both panels well before switching takes place so that it can avoid the panel turn on time and reduce the duration of the switching transient. If the panels are turned on before switching, as one would expect, there is no need to consider panel turn on time in the transient time.   **Issue 1-1-3: the ranges of the transient period(s) between two PUCCH/PUSCH TDMed repetitions for FR1 UE**   * + Option 3: ranges from 10us to 15us depending on whether the switch from one transmission to the next is from the same antenna port or different antenna ports   Sub topic 1-2:  **Issue 1-2-1: whether there are additional RAN4 considerations that RAN1 shall account for a switching gap (blanked symbol(s)) between two PUCCH/PUSCH TDMed repetitions (with different UL beams)**   * + Option 5: For short subslot currently RAN4 only consider a one symbol gap in the case of the highest SCS and transient period is required on both sides of the symbol. For other cases, blanked symbol is not defined.   Sub topic 1-3:  **Issue 1-3-1: whether RAN4 foresees any additional complexity when applying cyclical beam mapping vs sequential beam mapping?**   * + Option 1: RAN4 does not see any additional complexity. Though the power consumption may be higher with cyclic switching on account of there being more switching events.   Sub topic 1-4:  **Issue 1-4-1: whether RAN1 can assume the same requirement as RB hopping with respect to transient period in current RAN4 requirements, if the two hops have different UL beams in addition to different RBs**   * + Option 1: Yes   Sub topic 1-5:  **Issue 1-5-1: whether different TX timing is considered for different UL beam transmissions**   * + Option 2: Tell RAN1 the same UL timing is assumed for different UL beam transmissions in current RAN4 requirements. |

### CRs/TPs comments collection

*Major close-to-finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

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| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

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|  | **Status summary** |
| **Sub-topic#1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

*Recommendations on WF/LS assignment*

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| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

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| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

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| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |