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

**Incheon, KR, 22 May – 26 May, 2023**

**Agenda item:** 8.8.5

**Source:** Moderator (Ericsson)

**Title:** Topic summary for [107][208] FR2\_multiRx\_part2

**Document for:** Information

# Introduction

The main Topics to be discussed are:

* L1-RSRP Measurements
* TCI State switching
* Receive Time Difference*.*

# Topic #1: L1-RSRP measurements

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2307188 | Nokia, Nokia Shanghai Bell | Observation 1: It was agreed that we focus on Multi Rx Rel18 only on intra-cell scenarios.  Observation 2: When performing SSB measurements on intra-cell, the SSB indexes will not be overlapping for different TRPs.  Observation 3: Resource set 1 and resource set 2 of Group based beam reporting are not necessarily transmitted and received in the same OFDM symbols.  **Proposal 1: RAN4 to consider non-simultaneous RS measurements from different TRPs for multi Rx L1-RSRP measurement delay.**  **Proposal 2: RAN4 to consider non-simultaneous RS measurements from different TRPs for Rel-17 group-based L1-RSRP report requirements.**  Observation 4: It is possible from RAN1/RAN2 specification to configure GBBR rel 17 with Set 1 containing a different type of RS than Set 2, e.g. Set 1 with SSB and Set 2 with CSI-RS.  **Proposal 3: RAN 4 to define requirements with a combination of SSB and CSI-RS for GBBR rel 17.**  Observation 5: L1 measurement delay can increase speed of group based reporting and therefore help UEs to quickly establish 4 layer MIMO with multiple TRPs.  Observation 6: Beam sweeping scaling factor influences beam failure detection and recovery time and can therefore influence the robustness of the beam tracking and how quickly the interruptions due to beam failure last.  Observation 7: Depending on advanced multi-Rx UE architectures, beam sweep scaling factor can be optimized in FR2-1 UEs.  Observation 8: Reducing beam sweeping factor N leads to performance gain in terms of better beam management performance and throughput performance due to faster link recovery.  **Proposal 4: Introduce signaling for the UE to indicate beam sweeping scaling factor.**  **Proposal 5: Send LS to RAN2 requesting UE assistance information for the UE to inform the current beam sweeping scaling factor, in the range 1 to 4.**  Observation 9: Groups reported in GBBR in rel-17 are for simultaneous reception, but it is not clear if groups provide increased number of layers.  Observation 10: Conditions under which a UE reports GBBR groups are currently unclear.  **Proposal 6: RAN 4 to discuss the requirements for group based beam reporting rel-17 to include conditions in which the UE reports a group**  **Proposal 7: The UE shall report a group in group-based beam reporting rel-17 if the following conditions are met for two reference signals RS#n and RS#m:**  **a. The experienced receive time difference between RS#n and RS#m does not exceed the UE supported maximum receive time difference**  **b. The difference between the RSRP level measurements from RS#n and RS#m does not exceed a threshold (e.g. X dB)**  **c. The combined rank when considering RS#n and RS#m is larger than the achievable rank from either RS#n or RS#m.**  **Proposal 8: RAN4 to define RRM requirements for GBBR-r17 reuse legacy L1-RSRP delay as a baseline with updated beam sweeping scaling factor.**  Observation 11: Mobility measurement events for L3 measurements do not distinguish among RS from different TRPs.  Observation 12: Determining requirement that mandates RS for GBBR be configured based on L3 report only makes sense if mobility events are updated to support TRP-based events.  **Proposal 9: L3 measurement results should not be considered as pre-condition for Rel-17 group-based L1-RSRP report.**  Observation 13: Beam sweeping scaling factor is used for calculating measurement delay for L1-RSRP, L1-SINR, RLM, link recovery procedures and TCI switching delay.  **Proposal 10: L1 measurement delay is considered for L1-RSRP, L1-SINR, group-based beam reporting, RLM, Link recovery procedures, and TCI switching.**  **Proposal 11: RAN 4 to consider enhancements for RRM requirements due faster beam sweeping for reducing L1-RSRP measurement delay based on signaled beam sweeping scaling factor without further conditions.**  Observation 14: The requirements for L1-RSRP measurement delay and L1-SINR measurement period are similar for multi Rx operation.  Observation 15: GBBR-r17 does not support L1-SINR reporting.  **Proposal 12: Changes in non-group-based L1-RSRP measurement delay due to multi Rx operation are also considered for L1-SINR.**  **Proposal 13: RAN4 to discuss the need of group based SINR reporting for simultaneous reception and inform RAN1 in case it is needed.** |
| R4-2307347 | Apple | Proposal 1: It is proposed to discuss if RAN4 needs to specify requirement for UE group-based beam reporting, including AoA offset, beam reporting criterion other than the one based on RSRP, and regular UE beam reporting to inform the beam pair is usable.  Proposal 2: It is proposed to specify measurement period requirement for GBBR, for both cases where UE uses one panel or two panels at a time for L1 measurements.  Observation 1: Whether and how much beam sweeping factor N can be reduced depends on UE L1 measurement strategy and on UE panel implementation.  Proposal 3: It is proposed to have a new UE capability of beam sweep factor for multi-RX capable UE. It is up to UE to report it (<8).  Proposal 4: Given a reduced beam sweeping factor, if the current L1-RSRP measurement period remains unchanged, the current scheduling/measurement restrictions can be relaxed.  Proposal 5: A new UE capability should be needed to indicate whether the UE can support simultaneous reception of data and L1 measurement. However, final decisions on UE capability are postponed until the relevant requirement nears its completion and the impact on UE implementation is clearly understood. |
| R4-2307280 | Qualcomm | **UE simultaneous Rx beams for mTRP support and UE Rx beam for L1 measurement/evaluation**  **Observation 1: UE Rx beam management and TRP beam selection for L1 measurements and reports are left to UE implementation.**   * **gNB Tx beam selection for L1 measurement report**   + **According to RAN1 specification, a selection of L1 measurement results among configured multiple measurement results is up to UE implementation.** * **UE Rx beam selection for L1 measurements**   + **UE may consider multiple criteria when selecting measurement results for the report, and it is also up to UE Rx beam codebook design.** * **UE L1 measurement for a measurement resource with simultaneously formed two beams**   + **When UE processes one measurement resource from a TRP, the UE may measure L1-RSRP received from one Rx beam or two Rx beams, which is up to UE implementation**   **Proposal 1: RAN4 to not assume the simultaneously formed beams are also optimal for other general purposes, e.g. the chosen beams may not maximize serving cell signal strength/quality, therefore RLM and BFD/CBD may not always be performed by using the chosen simultaneous beams particularly when the UE is in a situation where the radio link issues have to be more aggressively evaluated.**  **L1 Measurement Applicability**  **Proposal 2: Group-based L1 measurement period requirements are applicable only when a valid L3 measurement report associated with the L1 measurement resources was sent during the last [5] seconds**  **L1 Measurement Period Requirements**  **Proposal 3: A UE Rx beam sweeping factor of N during SSB-based L1 measurements can be lowered to N/2 only if any one of the following conditions is met:**   * **UE is configured with active TCI states from two TRPs, and the association between the TCI states and the TRPs is explicitly known to the UE, i.e.**   + **(single DCI based mTRP) at least one of the codepoints in the active TCI list for PDSCH includes two reference resources for qcl-TypeD from respective TRPs**   + **(multi DCI based mTRP) two CORESETs QCL’ed with two reference resources for qcl-TypeD are configured**   + **[SNR > XdB for each TRP, where rank > 2 is expected]** * **Group-based L1-RSRP measurement is configured based on L3 measurements for the same measurement resources** * **The above reduced beam sweeping factor can be subject to a new UE capability** * **The above reduced beam sweeping factor does not apply to RLM and LRL (BFD and CBD)** |
| R4-2307811 | LG Electronics Inc. | Proposal 1: Introduce reduced Rx beam sweeping factor for L1 measurements along with the capability of supported Rx beam sweeping factor while multi-Rx chains are active.  Proposal 2: Wait for RAN1 response to finalize whether to enhance L1-RSRP requirements |
| R4-2307953 | Xiaomi | **Observation 1: For the groupbasedbeamreporting-r17, there are two CSI resource sets can be configured and for each CSI resource set, it can be CSI-SSB resource set or nzp-CSI-RS resource set.**  **Observation 2: There exist the case that UE can have good L1-RSRP result of two different TRPs with measurement in TDM manner while it cannot guarantee such L1-RSRP result when received simultaneously.**  **Observation 3: The SSB-based and CSI-RS based L1-RSRP measurement delay are related to different beam sweeping factors.**  **Observation 4: For non-overlap of two panel assumption, there will be no beam sweeping factor reduction for SSB based L1-RSRP.**  **Observation 5: For fully overlap of two panel assumption, the beam sweeping factor can be enhanced from 8 to 4 for SSB based L1-RSRP.**  **Observation 6: Beam sweeping factor N for CSI-RS is based on the repetition configuration, maxNumberRxBeam UE capability and Nres\_per\_set configuration.**  **Proposal 1: Wait for RAN1 reply LS on the reference signal configuration.**  **Proposal 2: Based on GBBR, the L1-RSRP measurement should be done for two reference signals simultaneously.**  **Proposal 3: To define specific L1-RSRP measurement requirement for GBBR based on different RS sets configurations.**  **Proposal 4: How to report the beam pair is for UE implementation.**  **Proposal 5: UE behaviour when no good beam pair found can wait for RAN1 reply LS.**  **Proposal 6: The beam sweeping factor reduction can be a UE capability for SSB + SSB case.**  **Proposal 7: Wait for RAN1 reply LS for two CSI-RS based L1-RSRP.** |
| R4-2307574 | CMCC | ***Propasal 1: the L1-RSRP measurment delay requirements can be enhanced by introducing*** ***beam sweeping factor reduction.*** |
| R4-2308726 | ZTE Corporation | **Observation 1: Before receiving the group-based report, the NW is not sure about the beam pairs so would not schedule the data which has be simultaneously received with other data or RS. The UE would detect the RS in TDM manner.**  **Proposal 1: Given that valid group-based reporting is received by the NW, then the following combinations of simultaneous scheduling/configuration are possible:**   * **Data + Data** * **L1-RSRP SSB + L1-RSRP SSB** * **L1-RSRP CSI-RS + L1-RSRP CSI-RS** * **L1-RSRP CSI-RS + L1-RSRP SSB depends on RAN1 LS reply**   **Observation 2: For the case of a single panel has been down-selected by previous RRM measurement(named as Assumption 1, the Rx beam sweeping during L1-RSRP measurement is performed only by a single panel. While for other case(named as Assumption 2), the Rx beam sweeping during L1-RSRP measurement is performed by multiple panels.**  **Proposal 2: Under Assumption 1, i.e. L1-RSRP measurement is performed only by a single panel down-selected by RRM measurement, no room to reduce the scaling factor of Rx beam sweeping but the measurement restriction can be relaxed.**  **Proposal 3: Under Assumption 2, i.e. L1-RSRP measurement is performed by multiple panels, UE can perform partial beam sweeping by each panel at the same time. So the beam sweeping factor can be reduced.**   * **For the case of each panel can cover half of the fully beam directions, the beam sweeping factor can be reduced by a half, i.e. from N to N/2.** * **For other cases, the beam sweeping factor can be reduced from N to maximum[N1, N2], here N1and N2 refer to the number of beams covered by each panel respectively.**   **Proposal 4: The conditions of the enhanced fast beam sweeping during L1-RSRP measurement can be considered from the following aspects:**   1. **The UE perform the L1-RSRP measurement for a single TRP based on multiple panels;** 2. **At one measurement occasion, the UE is not scheduled to receive data from the other TPR;** 3. **Not binding to the group-based report, i.e. such enhancement is allowed before the group-based reporting(maybe this is not a type of condition);** 4. **UE is capable of this enhancement.**   **Proposal 5: Regarding the corresponding signalling and UE capability, to our understand, the common solution is applicable here, i.e. when the UE reports supporting such UE capability, then the NW need to indicate the UE whether enable such enhancement through the NW signalling.**  **Proposal 6: The group-based reporting is pure RAN1 enhancement, Since different from the legacy L1-RSRP measurement, it is necessary to discuss whether define new measurement requirements for group-based reporting from the following aspects:**   * **The potential mixed RSs measurement scheme;** * **The sample number;** * **The applicability condition.** |
| R4-2307718 | vivo | ***Proposal 1: When UE indicates reduced beam sweeping factor, the corresponding L1 measurement requirements can be enhanced without any additional conditions.***  ***Proposal 2: The UE capability is to indicat reduced beam sweeping factor. The candidate number can be {2, 4, 6} for FR2-1.***  ***Proposal 3: No specific new requirements for group-based beam reporting are necessary to be defined and existing L1-RSRP measurement requirements are applicable for group-based beam reporting.***  ***Proposal 4: How to choose beam pair for group-based beam reporting is up to UE implementation.***  ***Proposal 5: Periodic, semi-persistent and aperiodic report are supported for group-based beam reporting.*** |
| R4-2308504 | MediaTek inc. | **Observation 1: N cannot be reduced for all UEs because it depends on UE implementation.**  **Proposal 1: Reducing the value of N in L1 measurement (L1-RSRP/BFD/CBD/RLM) delay requirement should be up to UE’s capability.**  **Proposal 2: In L1 measurement (L1-RSRP/BFD/CBD/RLM) delay requirement, P factor should not be enhanced due to simultaneous L3 and L1 measurement is not supported in R18.**  **Proposal 3: L1-SINR is not in the scope of Rel-17 group-based beam reporting.**  **Proposal 4: Before UE sends Rel-17 GBBR, reuse legacy L1-RSRP measurement requirement for Rel-17 GBBR.**  **Proposal 5: After UE sends Rel-17 GBBR, whether UE can enhance L1-RSRP measurement requirement should be discussed further in RAN4.**  **Proposal 6: How UE selects beam pair has not specified in RAN1 and it’s up to UE implementation.**  **Proposal 7: No need to specify the behavior if UE cannot find a good beam pair with NW configured Rel-17 GBBR.**  **Proposal 8: All reporting type of periodic, semi-persistent, aperiodic report are supported for Rel-17 GBBR** |
| R4-2309657 | Samsung | **Proposal 1: RAN 4 not to consider beam sweeping factor reduction based on panel coverage information**  **Proposal 2:Introduce optional capability signaling for the UE to indicate beam sweeping scaling factor.**  **Proposal 3: RAN4 to define a capability parameter to indicate the minimum number of beam sweeping factor N for simultaneous reception if signaling is needed**  **Proposal 4: Use legacy L1-RSRP delay as baseline to define the measurement delay required for GBBR**  **Proposal 5 : The Psharing factor should be kept, and the existing Psharing factor definition can be re-used in Rel-18 multi-Rx WI** |
| R4-2308477 | OPPO | **Proposal 1: Beam sweeping factor reduction is feasible at least for SSB-based L1-RSRP, RLM and BFD/CBD measurement. FFS for CSI-RS based L1 measurement.**  **Observation 1: Different Rx Beam sweeping/adjustment schemes (e.g., non-overlapping, partial overlapping, or fully overlapping with previous swept directions) may lead to different beam sweeping factors.**  **Proposal 2: Study the impact of different Rx Beam sweeping/adjustment schemes on Rx sweep factor.**  **Proposal 3: How to choose beam pair that are going to be reported based on measurement results is up to UE implementation.**  **Proposal 4: The measurement delay required for GBBR can reuse legacy L1-RSRP delay.** |
| R4-2308700 | Huawei, HiSilicon | ***Proposal 1: For group-based beam reporting, RAN4 needs to investigate the conditions of the QCL configurations for CSI-RS resource used for group-based L1-RSRP measurements.***  ***Proposal 2: For group-based beam reporting, there is no need to consider faster beam sweeping for enhancing CSI-RS based L1-RSRP measurements.***  ***Observation 1: For SSB based L1-RSRP, beam sweeping factor reduction for faster beam sweeping will lead to reduce the beam sweeping coverage compared with legacy UE, which will degrade both beam direction coverage and the robustness of the UE against beam variation caused by UE rotation.***  ***Observation 2: If beam sweeping factor reduction for the purpose of faster beam sweeping is assumed for to SSB based L1-RSRP measurements with group-based beam reporting, then the SSB for group-based L1-RSRP reporting is not suitable to be used as source RS to provide beam reference for the CSI-RS resource which does not need to be paired.***  ***Observation 3: If beam sweeping factor reduction for the purpose of faster beam sweeping is assumed for SSB based L1-RSRP measurements with group-based beam reporting, then some measurement restrictions needs to be introduced, e.g. same SSB cannot be used for group-based L1-RSRP measurements and legacy L1-RSRP measurements.***  ***Proposal 3: For group-based beam reporting, beam sweeping factor reduction for the purpose of faster beam sweeping is not suggested to be used for enhancing SSB based L1-RSRP measurements due to performance degradation and additional measurement restrictions.***  ***Proposal 4: For R18 multi-Rx DL receptions, it is suggested not to consider simultaneous L1-RSRP measurements on a pair of RSs when one of them is SSB resource or CSI-RS resource with repetition on.***  ***Observation 4: For group-based beam reporting, a RS from one resource set cannot be always paired with any RS from the other resource set.***  ***Proposal 5: For group-based L1-RSRP measurements, two RSs from different resource sets cannot be always considered to be received simultaneous.*** |
| R4-2308024 | Ericsson | ***Proposal 1****: For simultaneous reception, the two different RSs (with different IDs) from different directions must be received in at least one overlapping measurement occasion during their respective measurement periods.*  ***Proposal 2****: The minimum amount of overlap needed for multi-rx requirements to apply is TBD (e.g., full overlap, partial overlap, at least X% of overlapping RS occasions during the measurement period, etc.).*  ***Proposal 3****: When two RSs are configured in time resources which are not fully overlapping, the simultaneous reception requirements are defined with respect to the common subset of time resources for the two RSs (which may result in a longer measurement period for a partially overlapping case than for a fully overlapping case with the same periodicity).*  ***Proposal 4****: UE shall continue measurements when switching to/from multi-rx operation occurs during the measurement period, but the more relaxed requirements (between the corresponding legacy and multi-rx requirements) shall apply for the impacted measurement period.*  ***Proposal 5****: If the UE needs to drop/restart the measurement upon the switching, then switching should not be more frequent than at least one measurement period.*  ***Proposal 6****: Since the reduction of the beam sweeping factor N is due to simultaneous reception attempts for the same RS, while the scope of the WI is simultaneous reception of* ***different*** *RSs, another reduction is necessary to fulfil the WI target.*  ***Proposal 7****: For multi-rx operation, the measurement period is enhanced by a new scaling parameter L, to account for simultaneous reception of* ***different*** *RSs. L=1 for non-simultaneous reception, L=TBD<1 (e.g., L=½ ) when multi-rx operation is activated and the necessary conditions for multi-rx operation are met.*   |  |  | | --- | --- | | *Configuration* | *TL1-RSRP\_Measurement\_Period\_CSI-RS (ms)* | | *non-DRX* | *max(TReport, ceil(M\*P\*N\*L)\*TCSI-RS)* | | *DRX cycle ≤ 320ms* | *max(TReport, ceil(1.5\*M\*P\*N\*L)\*max(TDRX,TCSI-RS))* | | *DRX cycle > 320ms* | *ceil(M\*P\*N\*L)\*TDRX* | | *Note 1: TCSI-RS is the periodicity of CSI-RS configured for L1-RSRP measurement. TDRX is the DRX cycle length. TReport is configured periodicity for reporting.*  *Note 2: the requirements are applicable provided that the CSI-RS resource configured for L1-RSRP measurement is transmitted with Density = 3.* | |   ***Proposal 8****: The following is a necessary condition for simultaneous reception:*  *UE has the multi-rx operation capability (to be replaced with the exact capability name, with a relevant reference in the specification).*  ***Proposal 9****: The following is a necessary condition for simultaneous reception:*  *UE is configured with dual TCI.*  ***Proposal 10****: The following is a necessary condition for simultaneous reception:*  *UE is not configured with CA or DC.*  ***Proposal 11****: The following is a necessary condition for simultaneous reception:*  *The simultaneously received RSs are in PCell only.*  ***Proposal 12****: The following is a necessary condition for simultaneous reception:*  *Both RSs and their associated signals in the QCL type D infos are detectable during the entire measurement period.*  ***Proposal 13****:* The following is a necessary condition in multi-rx requirements:  *The applicable side conditions are the conditions during the overlapping RS occasions (the conditions can be better in the non-overlapping occasions).*  ***Proposal 14****:* The following is a necessary condition in multi-rx requirements:  *The measured RS is being received simultaneously with another RS, where the two RSs have QCL-TypeD with different references, in at least one overlapping measurement occasion during the measurement period.* |

## Open issues summary

*Several issues related to L1-RSRP measurements are still open. The following open issues should be discussed in order to progress the work and proceed with the definition of the actual requirements.*

* Group based beam reporting requirements
* L1-RSRP measurement period requirements
* L1-SINR measurement period requirements
* Other issues

### Sub-topic 1-1: Group based beam reporting (GBBR) requirements

*Companies think requirements shall be introduced for group-based beam reporting. Introduce conditions so that UE reports GBBR only if the conditions are met.*

*Open issues and candidate options before meeting:*

**Issue 1-1-1: Requirements to be defined for GBBR**

* Proposals
  + Proposal 1: Conditions for beam pair reporting
  + Proposal 2: L1-RSRP delay for GBBR
* Recommended WF
  + Please discuss proposal 1 and 2 in following issues

**Conditions for beam pair selection:**

**Issue 1-1-2: Conditions for selecting beam pair to be reported in GBBR (depends on the outcome of issues 1-3-1)**

* Proposals
  + Option 1: if the following conditions are met for two reference signals RS#n and RS#m:
    - The experienced receive time difference between RS#n and RS#m does not exceed the UE supported maximum receive time difference
    - The difference between the RSRP level measurements from RS#n and RS#m does not exceed a threshold (e.g. X dB)
    - The combined rank when considering RS#n and RS#m is larger than the achievable rank from either RS#n or RS#m.
  + Option 2: Up to UE implementation
  + Option 3: AoA offset, beam reporting criterion other than the one based on RSRP, and regular UE beam reporting to inform the beam pair is usable.
* Recommended WF
  + Please check in the meeting that leaving it to UE implementation is acceptable

**L1-RSRP for GBBR:**

**Issue 1-1-3: Scenarios to be considered for Group-based beam reporting for L1-RSRP requirement**

* Proposals
  + - Case 1: Before UE send Rel-17 GBBR.
    - Case 2: After UE send Rel-17 GBBR
* Recommended WF
  + Agree on the case 1 and case 2.

**Issue 1-1-3-1: Group-based beam reporting L1-RSRP requirement for Case 1 (Before UE send Rel-17 GBBR)**

* Proposals
  + Option 1: Before UE sends Rel-17 GBBR, reuse legacy L1-RSRP measurement requirement for Rel-17 GBBR
  + Option 2: RAN4 to define RRM requirements for GBBR-r17 reuse legacy L1-RSRP delay as a baseline with updated beam sweeping scaling factor.
* Recommended WF
  + Discussion needed

**Issue 1-1-3-2: Group-based beam reporting L1-RSRP requirement for Case 2 (After UE send Rel-17 GBBR)**

* Proposals
  + Option 1: After UE sends Rel-17 GBBR, whether UE can enhance L1-RSRP measurement requirement should be discussed further in RAN4
  + Option 2: two RSs from different resource sets cannot be always considered to be received simultaneous
  + Option 3: It is proposed to specify measurement period requirement for GBBR, for both cases where UE uses one panel or two panels at a time for L1 measurements
  + Option 4: Based on GBBR, the L1-RSRP measurement should be done for two reference signals simultaneously
    - To define specific L1-RSRP measurement requirement for GBBR based on different RS sets configurations
  + Option 5: RAN4 to define RRM requirements for GBBR-r17 reuse legacy L1-RSRP delay as a baseline with updated beam sweeping scaling factor.
* Recommended WF
  + Need further discussion.

**Issue 1-1-4: Beam sweeping factor for GBBR**

* Proposals
  + Option 1: Consider beam sweeping factor agreed for GBBR also
  + Option 2:
    - there is no need to consider faster beam sweeping for enhancing CSI-RS based L1-RSRP measurements
    - beam sweeping factor reduction for the purpose of faster beam sweeping is not suggested to be used for enhancing SSB based L1-RSRP measurements due to performance degradation and additional measurement restrictions
* Recommended WF
  + Need further discussion

**Issue 1-1-5: Should the RS configured for GBBR be configured based on L3 report?**

* Proposals
  + Option 1: NO, not to introduce L1 RSRP and GBBR restrictions based on previous L3 reports
  + Option 2: Yes, group based L1 measurement period requirements are applicable only when a valid L3 measurement report associated with the L1 measurement resources was sent during the last [5] seconds
* Recommended WF
  + Need further discussion

**Issue 1-1-6: Assumptions on overlap conditions of RS measurement occasions for GBBR**

* Proposals
  + Option 1: enhanced requirements are defined only for full overlap
  + Option 2: enhanced requirements are defined also for partial overlap (the exact reduction for partial overlap is FFS)
  + Option 3: RAN4 to consider non-simultaneous RS measurements from different TRPs for Rel-17 group-based L1-RSRP report requirements
* Recommended WF:
  + Discussion is needed.

### Sub-topic 1-2: L1-RSRP measurement requirements

Many companies proposed that L1-RSRP measurement delay can be reduced by faster beam sweeping using multi-RX chains. In last meeting when can UE apply faster beam sweeping is FFS. In this meeting following issues are suggested for resolving FFS.

**Issue 1-2-1: Methods to achieve faster beam sweeping**

Most companies propose that faster beam sweeping is possible if UE signals some indication or capability.

* Proposals
  + Option 1: by UE indicating the sweeping scaling factor
  + Option 2: by optional UE capability indication
  + Option 3: The beam sweeping factor reduction can be a UE capability for SSB + SSB case
  + Option 4: Signal faster beam sweeping factor as a capability (e.g., it is signalled as L and not N)
  + Option 5: Send LS to RAN2 requesting UE assistance information for the UE to inform the current beam sweeping scaling factor, in the range 1 to 4.
* Recommended WF
  + Need further discussion

**Issue 1-2-2: Conditions under which beam sweeping reduction is possible that will in turn translates to measurement period reduction**

* Proposals
  + Proposal 1: if UE reports faster beam sweeping by capability or signalling indication, measurement period can be reduced without any additional conditions
    - Proposal 1a: Proposal 1 + while multi-Rx chains are active
  + Proposal 2: if any one of the following conditions is met:
    - UE is configured with active TCI states from two TRPs, and the association between the TCI states and the TRPs is explicitly known to the UE, i.e.
      * (single DCI based mTRP) at least one of the codepoints in the active TCI list for PDSCH includes two reference resources for qcl-TypeD from respective TRPs
      * (multi DCI based mTRP) two CORESETs QCL’ed with two reference resources for qcl-TypeD are configured
      * [SNR > XdB for each TRP, where rank > 2 is expected]
  + Proposal 3: It is possible to enhance the measurement delay under certain conditions, e.g.:
    - Condition #1: UE has the multi-rx operation capability (to be replaced with the exact capability name, with a relevant reference in the specification),
    - Condition #2: UE is configured with dual TCI,
    - Condition #3: UE is not configured with CA or DC,
    - Condition #4: The simultaneously received RSs are in PCell only,
    - Condition #5: Both RSs and their associated signals in the QCL type D infos are detectable during the entire measurement period,
    - Condition #6: The RSs are configured to have common (overlapping in time) RS occasions,
    - Condition #7: The side conditions, applied in the common RS occasions, hold.
    - Condition #8: The measured RS is being received simultaneously with another RS, where the two RSs have QCL-TypeD with different references.
* Recommended WF
  + Need further discussion

**Issue 1-2-3: Candidate values for beam sweeping factor reduction:**

* Proposals
  + Option 1: The candidate number can be {2, 4, 6} for FR2-1.
  + Option 2: It is up to UE to report it (<8).
  + Option 3: N during SSB-based L1 measurements can be lowered to N/2
* Recommended WF
  + Need further discussion

**Issue 1-2-4: Assumptions on overlap conditions of RS measurement occasions for L1-RSRP**

* Option 1: enhanced requirements are defined only for full overlap
* Option 2: enhanced requirements are defined also for partial overlap (the exact reduction for partial overlap is FFS)
* Option 3: RAN4 to consider non-simultaneous RS measurements from different TRPs for multi Rx L1-RSRP measurement delay

Recommended WF:

Discussion is needed.

**Issue 1-2-5: Other issues on Measurement period**

**Issue 1-2-5-1: UE behaviour during multi-RX operation**

* Proposals
  + Proposal 1: UE shall continue measurements when switching to/from multi-rx operation occurs during the measurement period, but the more relaxed requirements (between the corresponding legacy and multi-rx requirements) shall apply for the impacted measurement period.
  + Proposal 2: If the UE needs to drop/restart the measurement upon the switching, then switching should not be more frequent than at least one measurement period.
* Recommended WF
  + Need further discussion

**Issue 1-2-5-2: Measurement period**

* Proposals
  + Proposal 1: For multi-rx operation, the measurement period is enhanced by a new scaling parameter L, to account for simultaneous reception of different RSs. L=1 for non-simultaneous reception, L=TBD<1 (e.g., L=½ ) when multi-rx operation is activated and the necessary conditions for multi-rx operation are met.

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| --- | --- |
| *Configuration* | *TL1-RSRP\_Measurement\_Period\_CSI-RS (ms)* |
| *non-DRX* | *max(TReport, ceil(M\*P\*N\*L)\*TCSI-RS)* |
| *DRX cycle ≤ 320ms* | *max(TReport, ceil(1.5\*M\*P\*N\*L)\*max(TDRX,TCSI-RS))* |
| *DRX cycle > 320ms* | *ceil(M\*P\*N\*L)\*TDRX* |
| *Note 1: TCSI-RS is the periodicity of CSI-RS configured for L1-RSRP measurement. TDRX is the DRX cycle length. TReport is configured periodicity for reporting.*  *Note 2: the requirements are applicable provided that the CSI-RS resource configured for L1-RSRP measurement is transmitted with Density = 3.* | |

* Recommended WF
  + Need further discussion

**Issue 1-2-6: Other issues to be discussed in other thread**

* Proposals
  + Option 1: L1 measurement delay is considered for RLM, Link recovery procedures
  + Option 2: Beam sweeping factor reduction is feasible at least for SSB-based RLM and BFD/CBD measurement
  + Option 3: The above reduced beam sweeping factor does not apply to RLM and LRL (BFD and CBD)
  + Option 4: L1 measurement delay is considered for L1-RSRP, L1-SINR, group-based beam reporting, RLM, Link recovery procedures, and TCI switching.
* Recommended WF
  + Suggest not to repeat discussion in this thread

### Sub-topic 1-3: Others

**Issue 1-3-1: Shall L1-SINR requirements be defined for the multi-RX UE**

* Proposals
  + Option 1: Yes
    - Proposal 1: Changes in non-group-based L1-RSRP measurement delay due to multi-Rx operation are also considered for L1-SINR
    - Proposal 2: RAN4 to discuss the need of group based SINR reporting for simultaneous reception and inform RAN1 in case it is needed
  + Option 2: NO
    - Proposal 3: Not discuss this issue because L1-SINR is not supported by Rel-17 group-based reporting.
* Recommended WF
  + Need further discussion

**Issue 1-3-2: UE capability for simultaneous reception of data and L1**

* Proposals
  + Option 1: A new UE capability should be needed to indicate whether the UE can support simultaneous reception of data and L1 measurement. However, final decisions on UE capability are postponed until the relevant requirement nears its completion and the impact on UE implementation is clearly understood
* Recommended WF
  + Agree on option 1. Companies, please confirm if the recommended WF is OK.

**Issue 1-3-3: Whether SSB+CSI-RS is supported for GBBR**

* Proposals
  + Option 1: Proposal 3: RAN 4 to define requirements with a combination of SSB and CSI-RS for GBBR rel 17
* Recommended WF
  + Wait for RAN1 LS reply.

**Issue 1-3-4: Conditions of the QCL configurations for CSI-RS resource used for GBBR**

* Proposals
  + Option 1: RAN4 needs to investigate the conditions of the QCL configurations for CSI-RS resource used for group-based L1-RSRP measurements.
    - E.g. FFS whether SSB used for non-GBBR can be configured as the source RS for CSI-RS used for GBBR.
* Recommended WF
  + Need further discussion

# Topic #2: TCI state switch

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2307131 | Nokia, Nokia Shanghai Bell | Proposal 1: For single-DCI scenario, RAN4 to reuse Rel-16 requirements for the case of DCI based TCI switching for PDSCH.  Proposal 2: For multi-DCI scenario, DCI based TCI state switch is per TRP. Hence legacy requirement can be reused and applied per TRP.  Proposal 3: In single-DCI scenario, legacy TCI state switching requirements apply for MAC-CE based TCI indication method for PDCCH.  Proposal 4: In multi-DCI scenario, legacy requirements for MAC-CE based TCI state switch for PDCCH apply per TRP.  Observation 1: Existing defined requirements for RRC-based TCI state switch delay apply only when one TCI state is configured in RRC state list.  Proposal 5: A switch from single TCI state to dual TCI state for PDCCH is a switch between single-DCI and multi-DCI scenarios, which involves RRC signalling. Hence, RRC based TCI state switch delay requirements will apply and requirements need to be updated for this case.  Proposal 6: For single DCI scenario, if a pair of TCI states is activated by MAC-CE command in the active TCI state list, include the first SSB of each TCI state in the activation delay.  Proposal 7: Tfirst-SSB is not included in the active TCI state list update delay for a target TCI state that is already in the active TCI state list.  Proposal 8: For multi-DCI scenario, active TCI state list update to dual TCI states is not considered.  Proposal 9: For MAC-CE based TCI state switch delay, define requirements also for unknown target TCI state.  Proposal 10: RAN4 to add the following in the existing known conditions,” In case of simultaneous reception, dual TCI states are configured based on beams reported by the UE in Rel-17 group-based L1-RSRP report”. |
| R4-2307283 | Qualcomm Incorporated | Proposal 1: If RAN4 agrees to define RRC based TCI activation, the requirement will be only for mDCI based mTRP mode, particularly when a second CORESET to enable mDCI based mTRP is configured by NW.  Proposal 2: RAN4 to not define MAC CE based dual TCI state switch delay requirements for unknown TCI state  Proposal 3: The known condition of dual TCI state switch for mTRP is based on Rel-17 group-based L1-RSRP measurement and report  Proposal 4: Tfirst-SSB defined for the existing TCI state switch delay requirements can be reused for dual TCI switch in mTRP if the definition of Tfirst-SSB is redefined to account for two TDM’ed source SSBs in the QCL chains with two TRPs |
| R4-2307349 | Apple | Proposal 1: To accommodate possible RF/BB implementation constraints in dual TCI switching, it is proposed to add 250us additional delay.  Proposal 2: For single DCI based TCI state switch, the current requirement can be used as a baseline. In addition, It is proposed to consider 250us additional delay to accommodate potential RF and/or L1-RSRP measurement and processing constraint.  Proposal 3: For multi-DCI based TCI state switch, only consider specifying requirements when TCI switching commands are received in the same slot. In addition, It is proposed to consider 250us additional delay to accommodate potential RF and/or L1-RSRP measurement and processing constraint.  Proposal 4: It is proposed to discuss and decide UE behavior in case the UE does not support the two configured target TCI states simultaneously.  Proposal 5: Option 2 is preferred as it gives network more flexibility to configure TCI states, under the condition that all the RSs on the same TCI chain needs to remain detectable during TCI switching. |
| R4-2307721 | vivo | Proposal 1: RRC triggered TCI state configuration is only considered after feasibility is confirmed.  Observation 1: MAC-CE based Dual TCI states switching requirements for PDCCH repetition and PDCCH with multi-DCI is relevant to 4-layer MIMO.  Proposal 2: For MAC CE based dual TCI states switch, requirements are specified for both single-DCI PDCCH repetition and multi-DCI PDCCH.  Proposal 3: Requirements for MAC-CE based dual TCI states switch delay for PDCCH reception are also defined for unknown + unknown case.  Proposal 4: Requirements for single-DCI based dual TCI states switch delay for PDSCH reception are to reuse legacy requirements as baseline.  Proposal 5: Requirements for multiple-DCI based dual TCI states switch delay for PDSCH reception are to reuse legacy requirements as baseline.  Proposal 6: Known/unknown conditions for dual TCI states switch can be defined as follows.  The TCI state is known if the following conditions are met:  - During the period from the last transmission of the RS resource used for the L1-RSRP measurement reporting for the target TCI state to the completion of active TCI state switch, where the RS resource for L1-RSRP measurement is the RS in target TCI state or QCLed to the target TCI state  - TCI state switch command is received within 1280 ms upon the last transmission of the RS resource for beam reporting or measurement  - The UE has sent at least one group-based L1-RSRP report configured with groupBasedBeamReporting or groupBasedBeamReporting-r17 and  - the target dual TCI states are based on reported RS resources pair within one group, or  - the target dual TCI states are QCL-ed to reported RS resources pair within one group  - The TCI state remains detectable during the TCI state switching period  - The SSB associated with the TCI state remain detectable during the TCI switching period  - SNR of the TCI state ≥ -3dB  Otherwise, the TCI state is unknown.  Proposal 7: For active TCI state list update for addition of a new dual TCI states, legacy requirements is reused if T/F tracking for the dual TCI states is based on single SSB.  Proposal 8: For active TCI state list update for addition of a new dual TCI states, the total update delay is based on SSB with longer delay if T/F tracking for the dual TCI states is based on different SSB. |
| R4-2307956 | Xiaomi | Observation 1: The timeDurationForQCL counts the OFDM symbols from the end of the last symbol of the PDCCH reception to the start of the first symbol of the PDSCH reception.  Proposal 1: For DCI-based TCI state switching delay, the legacy DCI based requirement apply for single-DCI.  Proposal 2: For DCI-based TCI state switching delay, the legacy requirement apply for each TCI state switching for each TRP for m-DCI.  Proposal 3: For MAC CE based TCI state switching, legacy single TCI state switching requirement apply per each switching.  Proposal 4: The legacy RRC based TCI state switching requirement can apply for above case.  Proposal 5: Only known case will be defined for MAC CE based and RRC based TCI state switching requirement. |
| R4-2308322 | Huawei, HiSilicon | Observation 1: UE supporting twoQCLTypeDforPDCCHRepetition, UE determine the first and second CORESET which with different QCL-typeD in overlapping PDCCH monitoring occasions based RAN1 spec.  Proposal 1: RAN4 to define requirements for TCI state switching for simultaneous PDCCH reception when UE is provided with twoQCLTypeDforPDCCHRepetition, where the TCI state of each PDCCH is controlled by separate MAC CE.  Proposal 2: Do not consider RRC triggered dual TCI state switching.  Proposal 3: For sDCI PDSCH TCI state switching, legacy requirements can apply to following cases:   single TCI to dual TCI   dual TCI to dual TCI  Observation 2: For dual TCI to single TCI when the target TCI is one of the source TCI (e.g. [RS1,RS2] to [RS1]), whether UE needs time to apply the TCI states depends on whether UE is still in mTRP mode.  Proposal 4: For dual TCI to single TCI when the target TCI is one of the source TCI (e.g. [RS1,RS2] to [RS1]), there is no TCI switching delay when UE is configured with GBBR and is NOT configured with non-GBBR.  Observation 3: For DCI based TCI switching for mDCI, when the PDSCH scheduled by different TRP are not overlapped, legacy DCI-based TCI state switching requirements can apply.  Observation 4: For mDCI, simultaneous PDSCH reception is for the case when PDSCH are fully/partially overlapped in time domain with different QCL-TypeD.  Proposal 5: For mDCI, for DCI based TCI state switching for simultaneous PDSCH reception, legacy TCI switching requirements can apply independently, provided that the time offset between the reception of the latter DCI among DCIs with different corsetPoolIndex scheduling simultaneous PDSCH reception to the earlier PDSCH shall be larger than timeDurationForQCL.  Proposal 6: For simultaneous PDCCH reception for PDCCH repetition, the legacy MAC CE based TCI state switching requirements can apply to each PDCCH TCI switching triggered by individual MAC CE for known case.  Proposal 7: Only define known case for MAC CE based dual TCI states switch delay for PDCCH reception.  Proposal 8: Dual TCI state for simultaneous reception are configured based on reported beam pair or RS QCL-ed with reported beam pair reported in GBBR. |
| R4-2308479 | OPPO | Proposal 1: Specify simultaneous dual TCI states switching firstly (e.g., dual TCI to dual TCI).  Proposal 2: Do not to consider the transition of two TCI state and one TCI state at first phase.  Proposal 3: RAN4 to define DCI based dual TCI state switch delay requirements:   * For the case of Single DCI,   + the same command triggers dual TCI state switching. Additional uncertainty time should be considered based on the legacy single TCI state switching delay.   + Defined for known case only. * For the case of Multiple DCI,   + each TCI state is changed by independent procedure with different triggering commands. Legacy requirements for each TCI state switching delay can be reused.   + Defined for known case only. |
| R4-2308507 | MediaTek inc. | Proposal 1: For dual TCI state switching, only define the requirement for the case when two indicated TCI states are known.  Proposal 2: Known TCI state definition for dual TCI states:  1. The dual TCI states of reference signals were included in Rel-17 group-based beam reporting, or  2. The dual TCI states which are QCL type D with the reference signals were included in Rel-17 group-based beam reporting.  Proposal 3: For detectable condition, all RSs in the same TCI chain for the target TCI state should remain detectable during the entire measurement/evaluation/TCI state switch period.  Proposal 4: T/F tracking for the dual TCI states are based on different SSBs in this WI.  Proposal 5: Not to consider RRC based TCI state switch in this WI. |
| R4-2309591 | Ericsson | 1. RAN4 to agree that, with the existing signalling mechanism, RRC based dual TCI state switching is not possible. 2. Dual to single TCI state switching using RRC is already covered by legacy requirements. 3. Requirements for MAC CE based dual TCI states switch delay for PDCCH reception are defined for known case only. 4. When dual TCI states are only configured based on beams reported in GBBR, dual TCI states are considered known if they are reported in GBBR and the report is sent in last 1280ms. 5. When dual TCI states which are QCLed to beam pair reported in GBBR can be configured, dual TCI states are considered known if the beam is reported in last 1280 ms and the dual TCI states are QCLed to last beam pair reported in GBBR. 6. Processing delay for single or dual DCI/MAC CE is the same as legacy. 7. For single DCI based and multi-DCI based schemes, RAN4 to reuse the legacy requirements for DCI based dual TCI state switch for PDSCH reception 8. For single DCI based and multi-DCI based schemes, RAN4 to reuse the legacy requirements for MAC-CE based dual TCI state switch for PDCCH reception. 9. RAN4 to investigate the UE behaviour when it is not able to receive simultaneously on the dual TCI states. 10. Active TCI state list delay shall include the delay for acquiring fine timing of both the TCI states and the timing acquisition is a parallel process. |

## Open issues summary

*Several issues related to TCI State Switching are still opened. The following open issues should be discussed in order to clearly identify the scope of the discussion and proceed with the definition of the actual requirements.*

* General principles for defining requirements
* DCI based TCI state switch
* MAC CE based TCI state switch
* RRC based TCI state switch
* Known conditions
* Active TCI state list update

### Sub-topic 2-1: General principle for defining requirements

**Issue 2-1-2: TCI switch command reception constraints for defining requirements**

* Proposals
  + Proposal 1: For MAC CE based dual TCI states switch, requirements are specified for both single-DCI PDCCH repetition and multi-DCI PDCCH.
  + Proposal 2: RAN4 to define requirements for TCI state switching for simultaneous PDCCH reception when UE is provided with twoQCLTypeDforPDCCHRepetition, where the TCI state of each PDCCH is controlled by separate MAC CE.

**Issue 2-1-3: The TCI state reference signals reception for T/F tracking**

* Proposals
  + Proposal 1: Tfirst-SSB defined for the existing TCI state switch delay requirements can be reused for dual TCI switch in mTRP if the definition of Tfirst-SSB is redefined to account for two TDM’ed source SSBs in the QCL chains with two TRPs
* Recommended WF

**Issue 2-1-4: UE behaviour when TCI states are not supported**

* Proposals
  + Proposal 1: RAN4 to investigate the UE behaviour when it is not able to receive simultaneously on the dual TCI states.
  + Proposal 2: It is proposed to discuss and decide UE behaviour in case the UE does not support the two configured target TCI states simultaneously.
* Recommended WF
  + Need further discussion.

**Issue 2-1-5: Other proposals for further discussion**

* Proposals
  + For dual TCI to single TCI when the target TCI is one of the source TCI (e.g. [RS1,RS2] to [RS1]), there is no TCI switching delay when UE is configured with GBBR and is NOT configured with non-GBBR
* Recommended WF
  + Agree on the above proposal.

### Sub-topic 2-2: DCI based TCI state switch

**Issue 2-2-1: Single DCI based TCI state switch**

Background: For sDCI PDSCH TCI state switching, following cases may occur

* single TCI to dual TCI
* dual TCI to dual TCI
* dual to single (already covered by legacy requirements so RAN4 need not discuss this case)

It is moderator understanding that we are discussing single to dual and dual to dual TCI state switching.

* Proposals
  + For sDCI PDSCH TCI state switching, RAN4 to use
    - Option 1: Rel-16 requirements
    - Option 2: Re-16 requirements + additional 250µs delay
* Recommended WF
  + Need further discussion

**Issue 2-2-2: Multi DCI based TCI state switch**

In previous meeting following was agreed.

*• For each of the two TCI states, the TCI state switch is assumed to be independent.*

*o FFS on the definition/scope of “independency.”*

**Issue 2-2-2-1: Two TCI state switching are independent provided the DCI for TCI switch is received**

* Proposals:
  + Option 1: No constraint is needed on the reception of TCI switch command
  + Option 2: When TCI switch commands are received in the same slot
  + Option 3: When TCI switch commands are received at least timeDurationForQCL apart.
  + Option 3a: For mDCI, for DCI based TCI state switching for simultaneous PDSCH reception, legacy TCI switching requirements can apply independently, provided that the time offset between the reception of the latter DCI among DCIs with different corsetPoolIndex scheduling simultaneous PDSCH reception to the earlier PDSCH shall be larger than timeDurationForQCL.
* Recommended WF

Need further discussion

**Issue 2-2-2-2: Two TCI state switching are independent, and their delay requirement is**

* Proposals:
  + Option 1: Each TCI state switch delay can reuse legacy TCI state switch requirement
  + Option 2: Allow 250µs additional delay to the overall delay
* Recommended WF

Need further discussion

### Sub-topic 2-3: MAC CE based TCI state switch

**Issue 2-3-1-1: Single DCI non-SFN**

* Proposals
  + Option 1: In single-DCI scenario, legacy TCI state switching requirements apply for MAC-CE based TCI indication method for PDCCH
  + Option 2: For single DCI based TCI state switch, the current requirement can be used as a baseline. In addition, it is proposed to consider 250us additional delay to accommodate potential RF and/or L1-RSRP measurement and processing constraint
* Recommended WF
  + Need further discussion

**Issue 2-3-1-2: sDCI PDCCH repetition**

* + Proposal 1:
    - RAN4 to define requirements for TCI state switching for simultaneous PDCCH reception when UE is provided with twoQCLTypeDforPDCCHRepetition, where the TCI state of each PDCCH is controlled by separate MAC CE
    - For simultaneous PDCCH reception for PDCCH repetition, the legacy MAC CE based TCI state switching requirements can apply to each PDCCH TCI switching triggered by individual MAC CE for known case.
* Recommended WF
  + Check if proposal 1 is agreeable

**Issue 2-3-2: Multi-DCI non-SFN**

* Proposals
  + Proposal 1: legacy requirements for MAC-CE based TCI state switch for PDCCH apply per TRP
* Recommended WF
  + Check if proposal 1 is agreeable.

### Sub-topic 2-4: RRC based TCI state switch

**Issue 2-4-2: Whether to define requirements for RRC based TCI state switch**

* Proposals
  + Proposal 1: A switch from single TCI state to dual TCI state for PDCCH is a switch between single-DCI and multi-DCI scenarios, which involves RRC signalling. Hence, RRC based TCI state switch delay requirements will apply and requirements need to be updated for this case.
  + Proposal 2: If RAN4 agrees to define RRC based TCI activation, the requirement will be only for mDCI based mTRP mode, particularly when a second CORESET to enable mDCI based mTRP is configured by NW.
  + Proposal 3: RRC triggered TCI state configuration is only considered after feasibility is confirmed.
  + Proposal 4: Do not consider RRC triggered dual TCI state switching (e.g., because RRC triggered TCI state configuration is not needed for intra-cell multi-TRP scenario).
  + Proposal 5: RAN4 to agree that, with the existing signalling mechanism, RRC based dual TCI state switching is not possible or feasible.
  + Proposal 6: The legacy RRC based TCI state switching requirement can apply for dual to single TCI case
* Recommended WF
  + First discuss whether for which scenarios RRC based TCI state switching is possible
    - Dual TCI to single TCI
    - Single TCI to dual TCI
  + If RRC based is only possible for dual to single, existing requirements can be applicable. Please confirm this in meeting

### Sub-topic 2-5: Known conditions

**Issue 2-5-1: Requirements to be considered**

* Proposals
  + Proposal 1: For MAC-CE based TCI state switch delay, define requirements also for unknown target TCI state
  + Proposal 2: RAN4 to not define MAC CE based dual TCI state switch delay requirements for unknown TCI state
    - If RRC requirements are defined, consider only known case
* Recommended WF
  + Discuss following in the meeting.
    - If unknown dual TCI state switching can be defined, please confirm based on which report NW configures dual TCI states and how does NW know that indicated TCI states can be received simultaneously.
    - If the indicated TCI states are unknown, it may so happen that UE may not receive them simultaneously. If behaviour can be defined for this case, we can define unknown TCI state switching requirements

**Issue 2-5-2: Definition of known condition**

* Proposals
  + Proposal 1: RAN4 to add the following in the existing known conditions,” In case of simultaneous reception, dual TCI states are configured based on beams reported by the UE in Rel-17 group-based L1-RSRP report”.
    - The known condition of dual TCI state switch for mTRP is based on Rel-17 group-based L1-RSRP measurement and report
  + Proposal 2: dual TCI states which are QCLed to beam pair reported in GBBR can be configured is preferred as it gives network more flexibility to configure TCI states, under the condition that all the RSs on the same TCI chain needs to remain detectable during TCI switching
  + Proposal 3: Dual TCI state for simultaneous reception are configured based on reported beam pair or RS QCL-ed with reported beam pair reported in GBBR.
  + Proposal 4: Known TCI state definition for dual TCI states:
    - * The dual TCI states of reference signals were included in Rel-17 group-based beam reporting, or
      * The dual TCI states which are QCL type D with the reference signals were included in Rel-17 group-based beam reporting
  + Proposal 5:
    - * When dual TCI states are only configured based on beams reported in GBBR, dual TCI states are considered known if they are reported in GBBR and the report is sent in last 1280ms.
      * When dual TCI states which are QCLed to beam pair reported in GBBR can be configured, dual TCI states are considered known if the beam is reported in last 1280 ms and the dual TCI states are QCLed to last beam pair reported in GBBR
  + Proposal 6: The TCI state is known if the following conditions are met:

- During the period from the last transmission of the RS resource used for the L1-RSRP measurement reporting for the target TCI state to the completion of active TCI state switch, where the RS resource for L1-RSRP measurement is the RS in target TCI state or QCLed to the target TCI state

- TCI state switch command is received within 1280 ms upon the last transmission of the RS resource for beam reporting or measurement

- The UE has sent at least one group-based L1-RSRP report configured with groupBasedBeamReporting or groupBasedBeamReporting-r17 and

- the target dual TCI states are based on reported RS resources pair within one group, or

- the target dual TCI states are QCL-ed to reported RS resources pair within one group

- The TCI state remains detectable during the TCI state switching period

- The SSB associated with the TCI state remain detectable during the TCI switching period

- SNR of the TCI state ≥ -3dB

Otherwise, the TCI state is unknown.

* Recommended WF
  + Please discuss below moderator proposal to fine tune the wording or add any conditions or remove any conditions for known condition definition.
    - Dual TCI states are known if the
      * dual TCI states are based the on reported beam pair (i.e., RS resources pair) within one group, or
      * dual TCI states are QCL-ed to reported beam pair (i.e., RS resources pair) within one group
      * The dual TCI state remains detectable during the TCI state switching period
      * [All the RS in the TCI chain remain detectable]
      * RS configured for dual TCI states are reported in last [1280]ms

### Sub-topic 2-6: Active TCI state list update

**Issue 2-6-1: Active TCI state list update**

**Whether to differentiate Active TCI state list update for single and multi DCI**

* Proposals
  + Option 1: Yes
  + Option 2: No

**Active TCI state list update delay requirement**

* Proposals
  + Proposal 1: For single DCI scenario, if a pair of TCI states is activated by MAC-CE command in the active TCI state list, include the first SSB of each TCI state in the activation delay
  + Proposal 2: Tfirst-SSB is not included in the active TCI state list update delay for a target TCI state that is already in the active TCI state list
  + Proposal 3: For active TCI state list update for addition of a new dual TCI states, legacy requirements is reused if T/F tracking for the dual TCI states is based on single SSB.
  + Proposal4: For active TCI state list update for addition of a new dual TCI states, the total update delay is based on SSB with longer delay if T/F tracking for the dual TCI states is based on different SSB.
  + Proposal 5: T/F tracking for the dual TCI states are based on different SSBs in this WI
  + Proposal 6: Active TCI state list delay shall include the delay for acquiring fine timing of both the TCI states and the timing acquisition is a parallel process
  + Proposal 7: For multi-DCI scenario, active TCI state list update to dual TCI states is not considered.
* Recommended WF
  + Further discuss following moderator proposal
    - T/F tracking for the dual TCI states are based on different SSBs in this WI [and the timing acquisition is a parallel process].
      * Other conditions TBD during meeting discussion.

# Topic #3: Receive time difference

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2307190 | Nokia, Nokia Shanghai Bell | Observation 1: Existing network deployments are designed with maximum inter-site distance that is limited by CA/DC MRTD requirements.  Observation 2: If the MRTD is smaller than the maximum propagation delay difference the UE may experience in a cell, there is no way for the network to determine if MRTD is exceeded or not.  Observation 3: There is a maximum receive time difference between beam pair RSs that a multi-Rx UE can support to achieve optimum DL reception in multi-TRP scenarios.  Proposal 1: For mTRP GBBR, UE should select Beam pair RSs that have relative receive time difference not exceeding the UE supported maximum receive time difference. |
| R4-2307350 | Apple | Proposal 1: To consider MRTD larger than CP, there are many issues related to standards impact to consider, besides the UE implementation impact:   * The value of MRTD in the network * UE capability * Scheduling restriction * Support of 4-layer MIMO * How can the UE know the actual MRTD in the network?   Proposal 2: There is expected to be impact on beam pair selection due to different MRTD. Detailed analysis should be discussed when RAN4 makes a decision on whether to support MRTD > CP case.  Proposal 3: Whether UE should support receive timing difference larger than CP as an optional capability can be part of R19 scope discussion when RAN starts to discuss the R19 RAN4 package. |
| R4-2308323 | Huawei, HiSilicon | Observation 1: Based on RAN4 and RAN1 agreements, UE can support RTD > CP (as an optional UE capability) with MRTD/MTTD of 8/8.5us for both intra-cell and inter-cell mTRP.  Observation 2: There is minor specification impact to support RTD larger than CP since it only works as applicability conditions.  Observation 3: There is no need to repeat the discussion on implementation complexity since it was already agreed to be introduced as an optional UE capability.  Proposal 1: Define requirements for RTD>CP with optional UE capability for FR2 multi-Rx.  Proposal 2: Requirement enhancement under discussion are also applies to RTD>CP, and specific requirements can be discussed when necessary. |
| R4-2308508 | MediaTek inc. | observation 1: For timing difference between different antenna modules, the number of the FFT module, timing estimation/tracking/compensation will be doubled.  observation 2: Normally, MRTD > CP will not happen for intra-cell mTRP and prefer not to follow the conclusion of MIMO evo until they have more clear scenarios or conclusion.  Proposal 1: Do not consider MRTD > CP in this WI until MIMO evo has some conclusion could be considered in the scope of R18 Multi-RX. |
| R4-2308729 | ZTE Corporation | Proposal 1: If inter-cell mTRP is decided to be included in this WI, then the possibility of the receiving timing difference larger than CP exists.  Proposal 2: From the perspective of UE architecture, based on the assumption of independent RF chain and BB for multi-panel case, not applying any restriction on receiving timing difference is feasible.  Proposal 3: The total receiving timing difference can be seen as a trade-off between BS TAE and propagation delay difference. So as to control the total value, then smaller BS TAE should be guaranteed if not restrict the deployment of inter-cell scenario. |
| R4-2308922 | Ericsson | Observation 1: LS reply to RAN1 from RAN4 in MIMO Evolution WI have agreed large MRTD and MTTS for a capable UE for FR1 is 33/34.6 µs and MRTD/MTTD value for FR2 is 8/8.5 µs.  Observation 2: FR2 intra band with MRTD < CP will limit MRTD deployment.  Observation 3: The UE has separate panels. It is reasonable to assume that a UE with separate panels has separate timing and FFT.  Proposal 1: For intra cell multi–RX FR2 MRTD > CP, assume MRTD or 8 µs and MTTD or 8.5 µs, for a capable UE. |

## Open issues summary

MRTD for simultaneous reception is still under discussion. Below only the MRTD for simultaneous data (PDSCH+PDSCH) reception is discussed. MRTD for simultaneous measurements+ data or other cases can be discussed if such a scheme is agreed upon.

In last meeting only intra-cell scenario is agreed to be considered in Rel-18. Companies are requested to consider that agreement for further discussion.

### Sub-topic 3-1

*Sub-topic description:*

*Open issues and candidate options before meeting:*

**Issue 3-1-1: Whether to consider RTD larger than CP in multi-RX WI**

* Proposals
  + Proposal 1: Do not consider MRTD > CP in this WI until MIMO evo has some conclusion could be considered in the scope of R18 Multi-RX.
  + Proposal 2: Define requirements for RTD>CP with optional UE capability for FR2 multi-Rx.
    - Requirement enhancement under discussion are also applies to RTD>CP, and specific requirements can be discussed when necessary
  + Proposal 2a: For intra cell multi–RX FR2 MRTD > CP, assume MRTD or 8 µs and MTTD or 8.5 µs, for a capable UE.
  + Proposal 3: Whether UE should support receive timing difference larger than CP as an optional capability can be part of R19 scope discussion when RAN starts to discuss the R19 RAN4 package.
* Recommended WF
  + Needs further discussion on other proposals.

**Issue 3-1-2: Others**

* Proposals
  + Proposal 1: For mTRP GBBR, UE should select Beam pair RSs that have relative receive time difference not exceeding the UE supported maximum receive time difference
  + Proposal 2: There is expected to be impact on beam pair selection due to different MRTD. Detailed analysis should be discussed when RAN4 makes a decision on whether to support MRTD > CP case.
  + Proposal 3: To consider MRTD larger than CP, there are many issues related to standards impact to consider, besides the UE implementation impact:

• The value of MRTD in the network

• UE capability

• Scheduling restriction

• Support of 4-layer MIMO

• How can the UE know the actual MRTD in the network?

* Recommended WF
  + Further discussion on the proposals.