**3GPP TSG-RAN WG4 Meeting # 99-e R4-210XXXX**

**Electronic Meeting, May. 19th – 27th, 2021**

**Agenda item:** 9.4.7

**Source:** Moderator (Nokia, Nokia Shanghai Bell)

**Title:** Email discussion summary for [99-e][221] [NR\_RF\_FR2\_req\_enh2\_RRM](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_98_e/Inbox/Drafts/%5B98e%5D%5B230%5D%20NR_RF_FR2_req_enh2_RRM)

**Document for:** Information

# Introduction

The WID on NR RF Enhancements for FR2 RP-202107 has been approved in RAN#89e meeting. The purpose of this work item is to specify the following FR2 UE features and associated requirements including RF and RRM requirements. This email discussion is to define the RRM core requirements for inter-band CA in FR2 corresponding to section 9.4.7 in the agenda.

In last RAN4#98bis-e meeting, RAN4 reached agreements on the deployment and UE assumptions for CBM and IBM capable UEs and identified the focus of FR2 inter-band UL CA on IBM capable UEs. The agreements and open issues are captured in the way forward R4-2105769.

Based on the agreements, the target of this meeting is to discuss the MRTD requirements for CBM capable UEs, and also the RRM requirements in both FR2 inter-band UL and UL CA. The tentative target of email discussion for 1st round and 2nd round is indicated below:

* 1st round: Companies are expected to provide views and/or comments on the listed open issues.
* 2nd round: Converge on at least some of the RRM requirements in FR2 inter-band CA.

# Topic #1: Inter-band DL CA enhancements

Moderator comments: All the contributions discussing or partially discussing the RRM requirements for FR2 inter-band DL CA enhancements are listed here. According to the tdoc criteria in R4-2016602, all CRs will be postponed so the CR relevant to this topic is marked with ”~~strikethrough~~”.

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2108969](file:///C:\DuLei2019\RAN4\RAN4%2399e\Docs\R4-2108969.zip) | Qualcomm Incorporated | **MRTD for CBM FR2 Inter-band CA**  **Proposal 1: For CBM UEs in FR2 inter-band CA, MRTD shall not be larger than “CP length - UE Rx beam switch time - 2 x DL timing error”. For instance, assuming UE Rx beam switch time 200nsec and DL timing error 16.2nsec, MRTD shall not be larger than 350nsec.**  **Proposal 2: For CBM UEs in FR2 inter-band CA, if MRTD is larger than “CP length - UE Rx beam switch time - 2 x DL timing error”, serving cell(s) shouldn’t expect the UE to be able to receive/detect PDCCH(s) on search spaces including at least the first or last OFDM symbol of slot in a band where beam management reference resource(s) it not configured. FFS on multiple numerologies. FFS on further scheduling restrictions on PDCCH and/or PDSCH.**  **SCell activation for CBM UE**  **Proposal 3: For CBM UEs, SSB samples for Rx beam sweeping shouldn’t be accounted for in unknown SCell activation latency requirement.**  **Measurement and Scheduling restrictions for CBM UE**  **Proposal 4: RAN4 to further discuss in detail whether and how to introduce scheduling and measurement restrictions for the following sections:**   * **For RRM** * **9.2.5.3.3 Scheduling availability of UE performing measurements on FR2** * **9.10.2.6.2 Scheduling availability of UE performing CSI-RS based measurements in FR2** * **For Radio Link Monitoring** * **8.1.2.3 Measurement restrictions for SSB based RLM** * **8.1.3.3 Measurement restrictions for CSI-RS based RLM** * **8.1.7.3 Scheduling availability of UE performing radio link monitoring on FR2** * **For Link Recovery** * **8.5.2.3 Measurement restriction for SSB based beam failure detection** * **8.5.3.3 Measurement restrictions for CSI-RS beam failure detection** * **8.5.5.3 Measurement restriction for SSB based candidate beam detection** * **8.5.6.3 Measurement restriction for CSI-RS based candidate beam detection** * **8.5.7.3 Scheduling availability of UE performing beam failure detection on FR2** * **8.5.8.3 Scheduling availability of UE performing L1-RSRP measurement on FR2** * **8.5.8.3 Scheduling availability of UE performing L1-RSRP measurement on FR2** * **For L1-RSRP/SINR measurements (Serving cell measurement)** * **9.5.5.1 Measurement restriction for SSB based L1-RSRP** * **9.5.5.2 Measurement restriction for CSI-RS based L1-RSRP** * **9.5.6.3 Scheduling availability of UE performing L1-RSRP measurement on FR2** * **9.8.5.1 Measurement restriction if SSB configured for L1-SINR Measurement** * **9.8.5.2 Measurement restriction if CSI-RS configured for L1-SINR measurement** * **9.8.5.3 Measurement restriction if CSI-IM configured for L1-SINR measurement** * **9.8.6.3 Scheduling availability of UE performing L1-SINR measurement on FR2** |
| [R4-2109256](file:///C:\DuLei2019\RAN4\RAN4%2399e\Docs\R4-2109256.zip) | Xiaomi | **Observation 1: When the MRTD is larger than CP, the demodulation performance can be significantly degraded at any DL symbol(s) due to the unpredictable UE Rx beam switching.**  **Observation 2: For the CBM capable UE, the MRTD should be smaller than CP length and should not be defined based on FR2 inter-band TAE requirement, otherwise the unpredictable interruption is expected to UE.**  **Proposal 1: MRTD requirements for CBM UEs shall not rely on FR2 inter-band TAE requirement.**  **Proposal 2: For FR2 inter-band DL CA with CBM, the MRTD shall be defined as 260ns.**  **Observation 3: if the single beam forming is shared by both bands, the existing interruption requirement of intra-band CA should be applied.**  **Observation 4: if the multiple beam forming is used and each dedicated to one band, for the cell(s) in the band including aggressor CC, the existing interruption requirement of intra-band CA shall be applied. And for the victim cell in the band without aggressor CC, the existing interruption requirement of inter-band CA shall be applied.**  **Proposal 3: For inter-band CA with CBM, the existing Rel-16 interruption requirements of intra-band CA shall be applied.** |
| [R4-2109546](file:///C:\DuLei2019\RAN4\RAN4%2399e\Docs\R4-2109546.zip) | NTT DOCOMO, INC. | **Proposal 1: If there are no critical issues such as connectivity problem or significant throughput degradation, the MRTD value for FR2 inter-band CA for CBM UEs should be defined based on existing inter-band CA requirement to keep the deployment flexibility.**  **Proposal 2: Symbol level alignment should be within MRTD value if the MRTD value is longer than CP length.**  **Proposal 3: MRTD should be derived as summation of TAE value and propagation time difference, i.e. MRTD = TAE + Δ\_propagation\_time** |
| [R4-2109613](file:///C:\DuLei2019\RAN4\RAN4%2399e\Docs\R4-2109613.zip) | vivo | **Proposal 1: For the MRTD value for CBM scenario for FR2 inter-band CA, prefer to use option 3, i.e., 260ns. It is ok to use option 2 as well.**  **Proposal 2: If MRTD value is 260ns, then the symbol level alignment is within the CP length. Otherwise if the MTRD value depends on UE capabilities, then whether the symbol level alignment is within the CP length or MRTD value also depends on UE capabilities.**  **Proposal 3: For the issue where performance degradation due to Rx beam switching, we support option 2 and ok with option 2b and 2c.** |
| [R4-2109706](file:///C:\DuLei2019\RAN4\RAN4%2399e\Docs\R4-2109706.zip) | LG Electronics Polska | **Proposal 1: Define MRTD of 260ns for inter-band DL CA based on CBM.** |
| [R4-2109751](file:///C:\DuLei2019\RAN4\RAN4%2399e\Docs\R4-2109751.zip) | ZTE Corporation | **Observation 1: TAE is defined as 3µs for BS type 1-O and BS type 2-O for inter-band CA case.**  **Observation 2 : For case A, the TAE performance between CCs could be limited. However, this case is dependent on the operator’s deployment. Different bands are deployed at different periods, so it is difficult to guarantee the use of a common timing module for different CCs in different bands.**  **Observation 3: For case B, if GPS signal for both NR AAU is lost, the TAE performance between individual CCs is around 3µs.**  **Proposal 1: Take option 4, i.e.,define in Rel 17 MRTD for inter-band FR2 CA for CBM as 3 µs.** |
| [R4-2109854](file:///C:\DuLei2019\RAN4\RAN4%2399e\Docs\R4-2109854.zip) | MediaTek inc. | **Observation 1: AGC adjustment will cause unexpected interruption when MRTD is more than CP length.**  **Proposal 1: Supporting MRTD = 260 ns. If no consensus, do not define any requirements for CBM UEs.** |
| [R4-2109888](file:///C:\DuLei2019\RAN4\RAN4%2399e\Docs\R4-2109888.zip) | NEC | **Proposal 1: RAN4 to agree that MRTD is 3us for an UE which is capable of CBM.**  **Proposal 2: RAN4 to agree that symbol level alignment should be within MRTD value (3us) and not within the CP length.**  **Proposal 3: RAN4 to agree that UE can switch RX beams (for example if it can switch during start of UL to DL transition) without major performance degradation.**  **Proposal 4: RAN4 not to define any measurement restrictions for CBM operation in FR2 inter-band CA.**  **Proposal 5: When PCell/PSCell and the target SCell are in a FR2 band pair with CBM and the target SCell is unknown, RAN4 to agree on following principle for deriving the SCell activation delay requirements.**   * **L1-RSRP measurement delay is not required in SCell activation delay.** * **SSB samples for Rx beam sweeping is not required in SCell activation delay.** |
| [R4-2110059](file:///C:\DuLei2019\RAN4\RAN4%2399e\Docs\R4-2110059.zip) | OPPO | **Observation 1: Demodulation performance degradation due to Rx beam switch should be noted in MRTD requirements for CBM UE if MRTD is larger than CP.**  **Proposal 1: Propose MRTD = 260ns for FR2 inter-band CA with CBM.**  **Proposal 2: For CBM based FR2 inter-band CA, the existing interruption requirements of intra-band CA can be applied.**  **Observation 2: The SCell activation requirements of CBM capable UE for case 2 depend on both RF architecture and MRTD requirements for CBM type UE.**  **Proposal 3: SCell activation delay would be reduced for the case provided that PCell/PSCell and the target SCell are in a FR2 band pair with CBM and the target SCell is unknown, compared to the existing SCell activation delay requirements for FR1+FR2 CA.** |
| [R4-2110301](file:///C:\DuLei2019\RAN4\RAN4%2399e\Docs\R4-2110301.zip) | Huawei, HiSilicon | **Proposal 1: For CBM type UE, the MRTD requirement for FR2 inter-band CA shall be no shorter than the BS TAE requirement for FR2 inter-band CA, otherwise it will cause compatibility issue.**  **Proposal 2: It is suggested that the MRTD requirement for FR2 inter-band CA with CBM UE can be defined as 3us.**  **Proposal 3: RAN4 needs to identify the scenarios where UE Rx beam switching is needed and study whether there have performance impacts due to Rx beam switching for each scenario.**  **Proposal 4: CBM UE can perform RX beam switching without major performance degradation even if MRTD is larger than CP length.**  **Proposal 5: It is proposed the existing interruption requirements for inter-band CA in R15/R16 can be reused for CBM type UE in R17.**  **Proposal 6: For unknown target SCell, the existing SCell activation requirements in Case 2 with removing Rx beam sweeping time and L1-RSRP measurement time can be used for CBM type UE. The SCell activation delay Tactivation\_time for unknown target SCell in case 2 can be defined as:**   |  | | --- | | If the PCell/PSCell and the target SCell are in a FR2 band pair with common beam management, and the target SCell is unknown to UE and semi-persistent CSI-RS is used for CSI reporting, provided that the side condition Ês/Iot ≥ -2dB is fulfilled, then Tactivation\_time is:  - 6ms + TFirstSSB\_MAX + TSMTC\_MAX + Trs + THARQ + max(Tuncertainty\_MAC + TFineTiming + 2ms, Tuncertainty\_SP).  If the PCell/PSCell and the target SCell are in a FR2 band pair with common beam management, and the target SCell is unknown to UE and periodic CSI-RS is used for CSI reporting, provided that the side condition Ês/Iot ≥ -2dB is fulfilled, then Tactivation\_time is:  - 3ms + TFirstSSB\_MAX + TSMTC\_MAX + Trs + max {(THARQ + Tuncertainty\_MAC + 5ms + TFineTiming), (Tuncertainty\_RRC + TRRC\_delay)}. |   **Observation 1: CBM UEs only need to perform RLM/BFD/CBD/L1-RSRP measurements on one CC (PCC or PSCC).**  **Proposal 7: There is no need to introduce the measurement restriction requirements for FR2 inter-band CA with CBM UE.** |
| [R4-2110419](file:///C:\DuLei2019\RAN4\RAN4%2399e\Docs\R4-2110419.zip) | Ericsson | **Observation-1: There are many options before scheduling restrictions are needed, like available time in UL and DL (if carriers not full) and UL to DL switch, where UE could safely switch beams.**  **Observation-2: A beam switch could be performed safe within the DL2UL guard if properly performed.**  **Proposal-1: Any change in MRTD should not impact already defined BS TAE of 3 µs for FR2 inter-band CA; i.e. keep Rel-15 values for BS TAE unchanged.**  **Observation-3: We see a risk that if most UE opt for MRTD = 260 ns capability only and option 2 becomes a de facto option 3, MRTD = 260ns.**  **Observation-4: We do not see significant implementation simplifications of better site and transmission equipment re-use if we got to TAE = 520 ns.**  **Proposal-2:**   * **The beam management is implementation dependent, thus not applicable to all UEs and to all band combinations.** * **The relevant UEs should be identified and distinguished (e.g. via capability indication, etc.) and the restrictions shall not be applied (e.g. deployment restrictions, etc.) for all UEs and all band combinations for the future of NR.** * **An agreed and approved UE capability indication, as in the bullet above, is a precondition for proposals in this document.**   **Proposal-3: Define MRTD for inter-band FR2 NR CA with common beam management as 3 µs. This corresponds to option 4 in [1]**  **Proposal-5: Corresponding MTTD for inter-band FR2 NR CA with common beam management as 3.5 µs.** |
| [R4-2110949](file:///C:\DuLei2019\RAN4\RAN4%2399e\Docs\R4-2110949.zip) | Intel Corporation | **Observation 1: UE cannot use DL->UL switching guard period to resolve MRTD issue since changing UE RX beam before uplink doesn’t make sense. UE also cannot use UL->DL switching period since it is fully occupied by TTX2RX.**  **Observation 2: UE can use UL->DL switching together with a scheduling restriction on the first symbol at the SCell after UL->DL switch to accommodate Rx beam switching for CBM UEs.**  **Observation 3: UE can use SMTC window together with existing Rel-16 scheduling restrictions to accommodate Rx beam switching for CBM UEs.**  **Proposal 1: Introduce UE capability to support MRTD = 3us.**  **Proposal 2: RAN4 to agree on the baseline implementation which should be considered for CBM UEs which support capability of MRTD = 3us.**  **Observation 4: For the case when network implementation supports TAE ≤ 260ns no scheduling restrictions required irrespective of UE capability for MRTD=3us support.**  **Observation 5: For the case when network implementation supports 260ns < TAE ≤ [570]ns restrictions on SSB transmission should be applied irrespective of UE capability for MRTD=3us support: do not allow 240kHz SCS transmission, otherwise apply scheduling restrictions on one symbol before and one symbol after SSB transmission on SCell.**  **Observation 6: For the case when network implementation supports [570]ns < TAE ≤ 3us there are different options on which restrictions to apply:**   * **Restrictions on first and last symbol of each slot of SCell.** * **Restrictions on last symbols of each slot of both PCell and SCell. This will allow to keep the first symbol for PDCCH. This requires UE to identify the earliest CC and switch RX beam on its slot boundary.** * **Restrictions on first and last symbol of each slot of PCell. No benefits comparing to other options** * **Restrictions on first symbols of each slot of both PCell and SCell. No benefits comparing to other options**   **Proposal 3: Scheduling restrictions should be applied based on BS implementation for the max TAE support:**   * **For TAE ≤ 260ns – no scheduling restrictions** * **For 260ns < TAE ≤ [570]ns – restrictions on SSB transmission should be applied: no 240kHz SCS or scheduling restrictions on one symbol before and one symbol after SSB transmission on SCell** * **For [570]ns < TAE ≤ 3us – restrictions on first and last symbol of each slot of SCell, or restrictions on first symbols of each slot of both PCell and SCell**   **Proposal 4: Proposals 1-3 are summarized in Figure 1**   |  | | --- | | Figure 1. Block diagram for the scheduling restrictions to be applied for different MRTD/TAE support |   **Observation 7: CP should cover both MRTD and beam switch duration.**  **Proposal 5: RAN4 to force RF group to define requirements on beam switch delay for FR2**  **Proposal 6: The values 260ns and 570ns in proposals 3-4 should be changed to (290ns-TBeamSwitch) and (570-TBeamSwitch).** |
| [R4-2111280](file:///C:\DuLei2019\RAN4\RAN4%2399e\Docs\R4-2111280.zip) | Nokia, Nokia Shanghai Bell | General:   1. It is feasible to re-use Rel-15 baseline UE RRM requirements as baseline UE requirements for Rel-17 CBM capable UE. 2. Rel-15 RRM requirements can be re-used as baseline for Rel-17 FR2 inter-band CBM UE RRM requirements. RAN4 will discuss each requirement separately and update when needed the Rel-15/16 RRM requirements to cover specific CBM related requirements, if any.   MRTD:   1. Too tight MRTD for FR2 inter-band CA can lead to increased operation cost for the operator. 2. The MRTD for FR2 inter-band CA with CBM would be equal to BS TAE as defined in 38.104. 3. The MRTD requirements for inter-band CA in FR2 under CBM shall be 3us. 4. RAN4 should evaluate on the feasibility of UE to perform Rx beam switch within the DL2UL guard period for CBM capable UE in inter-band CA. 5. MRTD of 3us is agreed for inter-band CA in FR2 under CBM with a note stating ‘This requirement applies to the UE capable of common beam management for FR2 inter-band CA. If the receive time difference exceeds the cyclic prefix length of that SCS, demodulation performance degradation is expected for the first symbol of the slot.’.   RRM Requirements (other than MRTD):   1. Rel-15 CA related requirements are applicable as UE requirements for the CBM capable UE in Rel-17 inter-band CA scenario assuming reception on the UE side is within the MRTD and CP. 2. Rel-15 CA related requirements are applicable for Rel-17 FR2 inter-band CA for CBM even if the SCS between the bands is different. 3. If the DL timing between the bands is large, changing of the UE TCI state based on DL timing in band 1 may impact DL reception on band 2, which may lead to an loss of the DL signal in band 2. 4. Any UE impact from Rx timing difference between the bands should be identified and should be accounted in the UE requirements. 5. Existing non-IBM UE interruption requirements would be applicable for an inter-band CA CBM UE. 6. Existing non-IBM UE scheduling restriction requirements would be applicable for an inter-band CA CBM UE, but may need clarification aligned with the MRTD agreement 7. Measurement restriction requirements need to be defined for CBM capable UE for inter-band CA scenario. 8. Existing Measurement restriction requirements would be applicable for an inter-band CA CBM UE but may need clarification aligned with the MRTD agreement. 9. If the to-be-activated target SCell is unknown but PCell/PSCell is in FR2, the target SCell activation delay requirements defined for the scenario where there is at least one active serving cell in the band, apply. 10. The existing BFD/CBD requirements in Rel-16 can be applied for FR2 inter-band CA with CBM type UE. |

## Open issues summary

### Sub-topic 1-1: MRTD for common beam management

*Sub-topic description:* This sub-topic discusses the MRTD requirements for common beam management and potential performance impact in FR2 inter-band DL CA.

**Issue 1-1-1: MRTD value for FR2 inter-band CA**

*Agreements in GTW at RAN4#98bis-e meeting:*

* *Candidate options*
  + *Option 1: Do not define any requirements for CBM UEs for FR2 inter-band CA*
  + *Option 2: Introduce UE capability to support MRTD = 260ns and MRTD = 3us (Intel, NEC)*
  + *Option 3: MRTD = 260ns (Vivo, Apple, Intel, OPPO, Xiaomi, Qualcomm, LG, MTK)*
  + *Option 4: MRTD = 3us (NEC, Ericsson, Nokia, Huawei, Docomo, Softbank, AT&T, Verizon, ZTE)*
  + *Other options are not precluded*
  + *Note 1: Decision shall be made in RAN4 #99-e*
  + *Note 2: Companies are encouraged to bring further analysis on achievable MRTD from the network and UE perspectives and the possible impact on the implementation and performance*
* Proposals
  + Option 1: Do not define any requirements for CBM UEs for FR2 inter-band CA (Ericsson, Mediatek)
  + Option 2: Introduce UE capability (vivo, Intel)
    - Option 2a: Introduce UE capability to support MRTD = 260ns and MRTD = 3us (vivo)
    - Option 2b: Introduce UE capability to support MRTD = 3us (Intel)
      * RAN4 to agree on the baseline implementation which should
      * be considered for CBM UEs which support capability of MRTD = 3us (Intel)
  + Option 3: MRTD = 260ns (Xiaomi, Vivo, LG, Mediatek, OPPO)
  + Option 4: MRTD = 3us (Docomo, ZTE, NEC, Huawei, Ericsson, Nokia)
    - 3us if there are no critical issues such as connectivity problem or significant throughput degradation (Docomo)
    - An agreed and approved UE capability indication, as in the bullet above, is a precondition for proposals in this document. (Ericsson)
  + Option 5: MRTD shall not be larger than “CP length - UE Rx beam switch time - 2 x DL timing error” (Qualcomm)
    - E.g. no larger than 350ns assuming Rx beam switch time 200ns and DL timing error 16.2ns.
* Recommended WF
  + TBA

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| **Company** | **Comments** |
| Xiaomi | Support option 3, and we are fine with option 1. Regarding the capability, how to apply it? |
| Huawei | Support option 4, and we can compromise to option 1. |
| vivo | Support option 3 and option 2. We can accept option 1 is used as the last resort. |

**Issue 1-1-2: How to derive MRTD for FR2 inter-band CA?**

* Proposals
  + Option 1: MRTD = TAE + Δ\_propagation\_time (Docomo, NEC, Huawei, ZTE, Nokia, Ericsson)
    - TAE is 3µs, i.e. keep Rel-15 values for BS TAE unchanged
  + Option 2: MRTD requirements for CBM UEs shall not rely on FR2 inter-band TAE requirement. (Xiaomi)
* Recommended WF
  + TBA

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| **Company** | **Comments** |
| Xiaomi | Support option2, from UE perspective, if MRTD is derived from TAE defined in Rel-15, which is 3us, it may cause unpredictable interruption on serving cell. |
| Huawei | Support option 1. |
| vivo | Focus on issue 1-1-1 is sufficient. |

**Issue 1-1-3: Symbol level alignment assumption**

* Proposals
  + Option 1: Symbol level alignment should be within MRTD value if MRTD value is longer than CP length (Docomo, NEC)
  + Option 2: If MRTD value is 260ns, then the symbol level alignment is within the CP length. Otherwise if the MTRD value depends on UE capabilities, then whether the symbol level alignment is within the CP length or MRTD value also depends on UE capabilities (Vivo)
* Recommended WF
  + TBA

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| **Company** | **Comments** |
| Xiaomi | Support option 2 |
| Huawei | Support option 1. |
| vivo | Support option 2. |

**Issue 1-1-4: Performance degradation due to Rx beam switch**

* Proposals
  + Option 1: UE can switch RX beams without major performance degradation even if MRTD is larger than CP length (NEC, Huawei, Ericsson)
    - Option 1a: It can switch during start of UL to DL transition (NEC)
    - Option 1b: UE could perform Rx beam switching within UL-DL switching period or the non-scheduled symbols without causing performance degradation (Huawei)
    - Option 1c: A beam switch could be performed safe within the DL2UL guard if properly performed (Ericsson, Nokia)
  + Option 2: Any timing impacts should be identified and should need to be accounted in the UE requirements (OPPO, Nokia, Vivo, Qualcomm).
    - Option 2a: Demodulation performance degradation due to Rx beam switch should be noted in MRTD requirements for CBM UE if MRTD is larger than CP. (OPPO, Nokia)
      * With a note stating ‘This requirement applies to the UE capable of common beam management for FR2 inter-band CA. If the receive time difference exceeds the cyclic prefix length of that SCS, demodulation performance degradation is expected for the first symbol of the slot.’ (Nokia)
    - Option 2b: For CBM UEs in FR2 inter-band CA, if MRTD is larger than CP length with respect to serving cell numerology, serving cell(s) shouldn’t expect the UE to be able to receive/detect PDCCH(s) on search spaces including at least the first or last OFDM symbol of slot in a band where beam management reference resource(s) it not configured. FFS on multiple numerologies. FFS on further scheduling restrictions on PDCCH and/or PDSCH. (vivo)
    - Option 2c: For CBM Ues in FR2 inter-band CA, if MRTD is larger than “CP length – UE Rx beam switch time – 2 x DL timing error”, serving cell(s) shouldn’t expect the UE to be able to receive/detect PDCCH(s) on search spaces including at least the first or last OFDM symbol of slot in a band where beam management reference resource(s) it not configured. FFS on multiple numerologies. FFS on further scheduling restrictions on PDCCH and/or PDSCH (Qualcomm)
    - Option 2d: If the receive time difference exceeds the cyclic prefix length of that SCS, demodulation performance degradation is expected for the first symbol of the slot. (Nokia)
  + Option 3: The performance degradation is significant and unacceptable (Xiaomi, Vivo, Mediatek).
    - Option 3a: When the MRTD is larger than CP, the demodulation performance can be significantly degraded at any DL symbol(s) due to the unpredictable UE Rx beam switching (Xiaomi, vivo)
    - Option 3b: AGC adjustment will cause unexpected interruption when MRTD is more than CP length (Mediatek)
  + Option 4: RAN4 needs to identify the scenarios where UE Rx beam switching is needed and study whether there have performance impacts due to Rx beam switching for each scenario. (Huawei)
  + Option 5: RAN4 should evaluate on the feasibility of UE to perform Rx beam switch within the DL2UL guard period for CBM capable UE in inter-band CA (Nokia)
* Recommended WF
  + TBA

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| **Company** | **Comments** |
| Xiaomi | Option 3 |
| Huawei | Support option 1.  As we mentioned in our paper, most of UE Rx beam switching operations can be performed within scheduling restricted symbols or DL2UL/UL2DL switching period. So, the UE performs Rx beam switching without major performance degradation when MRTD is larger than CP. |
| vivo | Ok with option 2 or 3 |

**Issue 1-1-5: Rx beam switch delay**

*Agreements at RAN4#98bis-e meeting: This should be discussed in RF session.*

* Proposals
  + Option 1: RAN4 to force RF group to define requirements on beam switch delay for FR2 (Intel)
    - The values 260ns and 570ns in proposals 3-4 should be changed to (290ns-TBeamSwitch) and (570-TBeamSwitch).
* Recommended WF
  + TBA

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| **Company** | **Comments** |
| Xiaomi | Whether to define beam switch delay for FR2 should be decided in RF session. |

### Sub-topic 1-2: RRM requirements for common beam management

*Sub-topic description:* This sub-topic discusses the RRM requirements other than MRTD and MTTD in case of CBM for FR2 inter-band DL CA.

**Issue 1-2-1: RRM requirements baseline**

* Proposals
  + Option 1: Rel-15 RRM requirements can be re-used as baseline for Rel-17 FR2 inter-band CBM UE RRM requirements. RAN4 will discuss each requirement separately and update when needed the Rel-15/16 RRM requirements to cover specific CBM related requirements, if any (Nokia)
    - Option 1a: Rel-15 CA related requirements are applicable as UE requirements for the CBM capable UE in Rel-17 inter-band CA scenario assuming reception on the UE side is within the MRTD and CP (Nokia)
    - Option 1b: Rel-15 CA related requirements are applicable for Rel-17 FR2 inter-band CA for CBM even if the SCS between the bands is different (Nokia)
* Recommended WF
  + TBA

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| **Company** | **Comments** |
| Xiaomi | Single beam-forming topology shared by two bands can be supported for inter-band CBM capable UE, and the antenna-to- ADC resources are shared across bands (same antenna, LNA, AGC, etc), this UE topology of inter-band CA with CBM is similar as intra-band CA case. |
| Huawei | RAN4 discuss whether R15 requirements can be reused in R17 separately for each RRM requirements. There is no need for further discussion on this issue. |
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**Issue 1-2-2: Interruption requirements**

* Proposals
  + Option 1: The existing Rel16 interruption requirements of intra-band CA shall be applied (Xiaomi, OPPO)
  + Option 2: Existing interruption requirements for inter-band CA in R15/R16 can be reused for CBM type UE in R17 (Huawei)
  + Option 3: Existing non-IBM UE interruption requirements would be applicable for an inter-band CA CBM UE. (Nokia)
* Recommended WF
  + TBA

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Xiaomi | As single beamforming topology and multiple beamforming topology can be supported for inter-band CA with CBM, if UE is implemented with single beamforming shared by two bands, theexisting interruption requirement of intra-band CA should be applied. |
| Huawei | Support option 2. |

**Issue 1-2-3: Scheduling restriction**

* Proposals
  + Option1: RAN4 to discuss in detail whether and how to introduce scheduling restriction for the following section (Qualcomm)
  + RRM
    - 9.2.5.3.3 Scheduling availability of UE performing measurements on FR2
    - 9.10.2.6.2 Scheduling availability of UE performing CSI-RS based measurements in FR2
  + Radio Link Monitoring
    - 8.1.7.3 Scheduling availability of UE performing radio link monitoring on FR2
  + Link Recovery
    - 8.5.7.3 Scheduling availability of UE performing beam failure detection on FR2
    - 8.5.8.3 Scheduling availability of UE performing L1-RSRP measurement on FR2
    - 8.5.8.3 Scheduling availability of UE performing L1-RSRP measurement on FR2
  + L1-RSRP/SINR measurements (Serving cell measurement)
    - 9.5.6.3 Scheduling availability of UE performing L1-RSRP measurement on FR2
    - 9.8.6.3 Scheduling availability of UE performing L1-SINR measurement on FR2
  + Option 2: There are many options before scheduling restrictions are needed, like available time in UL and DL (if carriers not full) and UL to DL switch, where UE could safely switch beams (Ericsson)
  + Option 3: Scheduling restrictions should be applied based on BS implementation for the max TAE support (Intel):
    - For TAE ≤ 260ns – no scheduling restrictions
    - For 260ns < TAE ≤ [570]ns – restrictions on SSB transmission should be applied: no 240kHz SCS or scheduling restrictions on one symbol before and one symbol after SSB transmission on SCell
    - For [570]ns < TAE ≤ 3us – restrictions on first and last symbol of each slot of SCell, or restrictions on first symbols of each slot of both PCell and SCell
  + Option 4: Existing non-IBM UE scheduling restriction requirements would be applicable for an inter-band CA CBM UE, but may need clarification aligned with the MRTD agreement (Nokia)
* Recommended WF
  + TBA

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| --- | --- |
| **Company** | **Comments** |
| Huawei | Scheduling restrictions requirements for FR2 inter-band CA with CBM can be introduced into the current scheduling availability requirements on FR2. |
| vivo | Ok with option 1 to have a case by case study |

**Issue 1-2-4: Measurement restriction**

* Proposals
  + Option1: RAN4 to discuss in detail whether and how to introduce scheduling restriction for the following section (Qualcomm)
  + Radio Link Monitoring
    - 8.1.2.3 Measurement restrictions for SSB based RLM
    - 8.1.3.3 Measurement restrictions for CSI-RS based RLM
  + Link Recovery
    - 8.5.2.3 Measurement restriction for SSB based beam failure detection
    - 8.5.3.3 Measurement restrictions for CSI-RS beam failure detection
    - 8.5.5.3 Measurement restriction for SSB based candidate beam detection
    - 8.5.6.3 Measurement restriction for CSI-RS based candidate beam detection
  + L1-RSRP/SINR measurements (Serving cell measurement)
    - 9.5.5.1 Measurement restriction for SSB based L1-RSRP
    - 9.5.5.2 Measurement restriction for CSI-RS based L1-RSRP
    - 9.8.5.1 Measurement restriction if SSB configured for L1-SINR Measurement
    - 9.8.5.2 Measurement restriction if CSI-RS configured for L1-SINR measurement
    - 9.8.5.3 Measurement restriction if CSI-IM configured for L1-SINR measurement
  + Option 2: RAN4 not to define any measurement restrictions for CBM operation in FR2 inter-band CA (NEC, Huawei).
    - CBM UEs only need to perform RLM/BFD/CBD/L1-RSRP measurements on one CC (PCC or PSCC).
  + Option 3: Measurement restriction requirements need to be defined for CBM capable UE for inter-band CA scenario. (Nokia)
    - Existing Measurement restriction requirements would be applicable for an inter-band CA CBM UE but may need clarification aligned with the MRTD agreement. (Nokia)
* Recommended WF
  + TBA

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| --- | --- |
| **Company** | **Comments** |
| Huawei | Support option 2.  There is no need to introduce layer 1 measurement restrictions between two FR2 inter-band CCs for CBM type UE, since CBM UE is not required to perform layer 1 measurements on multiple CCs. |

**Issue 1-2-5: SCell activation delay**

* Proposals
  + Principle: Case 2: if PCell/PSCell and the target SCell are in a FR2 band pair with CBM and the target SCell is unknown,
    - Option 1: the SCell activation requirements shall be reduced
      * Option 1a: SSB samples for Rx beam sweeping shouldn’t be accounted for in unknown SCell activation latency requirement. (Qualcomm, NEC, OPPO, Huawei)
      * Option 1b: L1-RSRP measurement delay is not required in SCell activation delay (NEC, OPPO, Huawei)
      * Option 1c: AGC settling time could be reduced for UE owing to following AGC settling in PCell/PSCell (OPPO)
      * Option 2: the target SCell activation delay requirements defined for the scenario where there is at least one active serving cell in the band, apply. (Nokia)
  + Text proposal:
    - Option 1: (Huawei)
      * If the PCell/PSCell and the target SCell are in a FR2 band pair with common beam management, and the target SCell is unknown to UE and semi-persistent CSI-RS is used for CSI reporting, provided that the side condition Ês/Iot ≥ -2dB is fulfilled, then Tactivation\_time is:

- 6ms + TFirstSSB\_MAX + TSMTC\_MAX + Trs + THARQ + max(Tuncertainty\_MAC + TFineTiming + 2ms, Tuncertainty\_SP).

* + - * If the PCell/PSCell and the target SCell are in a FR2 band pair with common beam management, and the target SCell is unknown to UE and periodic CSI-RS is used for CSI reporting, provided that the side condition Ês/Iot ≥ -2dB is fulfilled, then Tactivation\_time is:

- 3ms + TFirstSSB\_MAX + TSMTC\_MAX + Trs + max {(THARQ + Tuncertainty\_MAC + 5ms + TFineTiming), (Tuncertainty\_RRC + TRRC\_delay)}.

* + - Option 2: (Nokia)
      * For a UE supporting inter-band CA, when the SCell being activated belongs to FR2 and if there is at least one active serving cell on that FR2 band or on a supported inter-band CA FR2 combo, then Tactivation\_time is TFirstSSB+ 5ms provided:

- The UE is provided with SMTC for the target SCell, and

- The SSBs in the serving cell(s) and the SSBs in the SCell fulfil the condition defined in clause 3.6.3,

- The parameter ssb-PositionsInBurst is same for the serving cell(s) and the SCell.

If the SCell being activated belongs to FR2 and if there is at least one active serving cell on that FR2 band, if the UE is not provided with any SMTC for the target SCell, Tactivation\_time is 3 ms, provided

- the RS (s) of SCell being activated is (are) QCL-TypeD with RS (s) of one active serving cell on that FR2 band.

* Recommended WF
  + TBA

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| --- | --- |
| **Company** | **Comments** |
| Xiaomi | if PCell/PSCell and the target SCell are in a FR2 band pair with CBM and the target SCell is unknown, the scaling factor due to Rx beam sweeping, the L1-RSRP measurement and reporting and TCI state activation delay are not required. |
| Huawei | Support option 1.  For the unknown target SCell in case 2, AGC settling time, cell search time and fine timing tracking time are still needed for CBM type UE. The value of Tactivation\_time for CBM type UE can be derived from the existing requirements with reducing both Rx beam sweeping time and L1-RSRP measurement delay. |

Issue 1-2-6: Beam management

* Proposals
  + Option 1: The existing BFD/CBD requirements in Rel-16 can be applied for FR2 inter-band CA with CBM type UE (Nokia)
* Recommended WF
  + TBA

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Xiaomi | Fine with the proposal |

### Sub-topic 1-3: MTTD for common beam management

*Sub-topic description:* This sub-topic discusses the MTTD requirements for common beam management.

*Agreements in RAN4#98bis-e-meeting:*

* *Issue 1-3-1: The MTTD value for FR2 inter-band CA with CBM* 
  + *Agreements:*
    - *It is not in the scope of Rel17 as it is related to CBM-based inter-band UL CA*

**Issue 1-3-1: The MTTD value for FR2 inter-band CA with CBM**

* Proposals
  + Option 1: 3.5 µs (Ericsson)
* Recommended WF
  + Given the agreements from RAN4#98bis-e meeting, it was recommended not to discuss MTTD in this WI.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Xiaomi | Support the recommended WF |
| Huawei | Agree with the recommended WF. |

## Companies views’ collection for 1st round

### Open issues

*Moderator’s comments: Companies please provide your comments in the tables below each separate sub-topic summary in section 1.2.*

### CRs/TPs comments collection

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

|  |  |
| --- | --- |
| **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.*

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

### CRs/TPs

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

*Note: The tdoc decisions shall be provided in Section 3 and this table is optional in case moderators would like to provide additional information.*

|  |  |
| --- | --- |
| **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)

# Topic #2: Inter-band UL CA

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2111281](file:///C:\DuLei2019\RAN4\RAN4%2399e\Docs\R4-2111281.zip) | Nokia, Nokia Shanghai Bell | 1. RAN4 to update the applicability of requirements in the specification to include FR2 inter-band UL CA. 2. The UL carrier reconfiguration only impact activate serving cells within the band of the UL carrier being reconfigured. 3. Only the band in which the UL BWP switch should be impacted by the BWP switch. 4. Current requirement regarding interruption requirement for a UE switching between two uplink carriers can be applied in Rel-17. 5. Clarify that the requirements apply for both frequency ranges. 6. Interruptions in DL due to SRS carrier switching in one of the two bands used in FR2 UL inter-band CA, will not cause interruptions in the DL of the 2nd band. 7. Wait for RF room on conclusion of applicable SRS carrier switching time for inter-band CA in FR2 |

## Open issues summary

### Sub-topic 2-1 RRM requirements for Independent beam management

*Agreements in RAN4#98bis-e-meeting:*

* *Issue 2-1-1: General* 
  + *Agreements:*
    - *The RRM requirements for FR2 inter-band CA based on CBM shall not be pursued in Rel-17*

**Issue 2-1-1: General**

* Proposals
  + Option 1: RAN4 to update the applicability of requirements in the specification to include FR2 inter-band UL CA. (Nokia)
* Recommended WF
  + TBA

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX |  |

**Issue 2-1-2: Interruption due to UL carrier RRC reconfiguration**

* Proposals
  + Option 1: The UL carrier reconfiguration only impact activate serving cells within the band of the UL carrier being reconfigured. (Nokia)
* Recommended WF
  + TBA

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei | The interruption is for both uplink and downlink of the active serving cells within the same FR. We suggest that the existing interruption requirements at UL carrier RRC reconfiguration can be reused in R17. |

**Issue 2-1-3: Interruption at active BWP switching**

* Proposals
  + Option 1: Only the band in which the UL BWP switch should be impacted by the BWP switch. (Nokia)
* Recommended WF
  + TBA

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei | For UE not capable of per-FR gap, the interruption due to active BWP switching is allowed to all other active serving cells. For UE capable of per-FR gap, the interruption due to active BWP switching is allowed to the other active serving cells in same FR. The current interruption requirements due to active BWP switching can be reused in R17. |

**Issue 2-1-4: DL interruption due to UE switching between two UL carriers**

* Proposals
  + Option 1: Current requirement regarding interruption requirement for a UE switching between two uplink carriers can be applied in Rel-17 (Nokia)
    - Clarify that the requirements apply for both frequency ranges
* Recommended WF
  + TBA

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei | The UE capability uplinkTxSwitchingPeriod is only applicable for FR1, and the current DL interruption requirements due to UE switching between two uplink carriers are also only applied in FR1. FFS this capability can be applicable for FR2. |

**Issue 2-1-5 DL interruption at NR SRS carrier based switching**

* Proposals
  + Option 1: Interruptions in DL due to SRS carrier switching in one of the two bands used in FR2 UL inter-band CA, will not cause interruptions in the DL of the 2nd band. (Nokia)
  + Option 2: Wait for RF room on conclusion of applicable SRS carrier switching time for inter-band CA in FR2 (Nokia)
* Recommended WF
  + TBA

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX |  |

## Companies views’ collection for 1st round

### Open issues

*Moderator’s comments: Companies please provide your comments in the tables below each separate sub-topic summary in section 2.2.*

### 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.*

|  |  |
| --- | --- |
| **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.*

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

### CRs/TPs

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

|  |  |
| --- | --- |
| **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)

*Moderator can provide summary of 2nd round here. Note that recommended decisions on tdocs should be provided in the section titled ”Recommendations for Tdocs”.*

# Recommendations for Tdocs

## 1st round

**New tdocs**

|  |  |  |
| --- | --- | --- |
| **Title** | **Source** | **Comments** |
| WF on … | YYY |  |
| LS on … | ZZZ | To: RAN\_X; Cc: RAN\_Y |
|  |  |  |

**Existing tdocs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-210xxxx | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics incl. existing and new tdocs.
2. For the Recommendation column please include one of the following:
   1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
   2. Other documents: Agreeable, Revised, Noted
3. For new LS documents, please include information on To/Cc WGs in the comments column
4. Do not include hyper-links in the documents

## 2nd round

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-210xxxx | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
| R4-210xxxx | WF on … | YYY | Agreeable, Revised, Noted |  |
| R4-210xxxx | LS on … | ZZZ | Agreeable, Revised, Noted |  |
|  |  |  |  |  |

Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics.
2. For the Recommendation column please include one of the following:
   1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
   2. Other documents: Agreeable, Revised, Noted
3. Do not include hyper-links in the documents