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

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

**Agenda item:** 10.2

**Source:** Moderator (Ericsson)

**Title:** Email discussion summary for [99-e][150] FS\_NR\_eff\_BW\_util

**Document for:** Information

# Introduction

This email discussion is for FS\_NR\_eff\_BW\_util study item. The main objective of the study is on efficient utilization of licensed spectrum that is not aligned with existing NR channel bandwidth. The following is the agreed agenda:

* Study on Efficient utilization of licensed spectrum that is not aligned with existing NR channel bandwidths
  + General and work plan
  + Evaluation of use of larger channel bandwidths than operator licensed bandwidth
  + Evaluation of use of overlapping UE channel bandwidths
  + Others

The following topics are discussed in this email thread:

Topic #1: General TR Update

Topic #2: Evaluation of Use of Larger Channel Bandwidth

Topic #3: Evaluation of Use of Overlapping UE Channel Bandwidths

# Topic #1: General TR Update

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

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2110487 | Ericsson | Updated draft TR 38.844 after RAN4#98bis-e |

## Companies views’ collection for 1st round

* + 1. 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*

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| **CR/TP number** | **Comments collection** |
| R4-2110487 | Company A |
| Company B |
|  |

* 1. Summary for 1st round
     1. Open issues

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

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| **CR/TP number** | **CRs/TPs Status update recommendation** |
| R4-2110487 | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #2: Evaluation of use of larger channel bandwidths

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

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2109427 | ZTE Wistron Telecom AB | Observation 1: UL transmission within the irregular bandwidth will not cause any co-existence issue.  Observation 2: In DL reception, the number of significance bits of ADC output will be reduced due to the interference of blanked PRBs from the other operator.  Proposal 1: RAN4 needs to specify the number of blanked PRBs for specifying RF requirements corresponding to the irregular bandwidth.  Proposal 2: RAN4 to define new REFSENS associated with a certain number of blanked PRBs for the use of WiderCBW. |
| R4-2110661 | Huawei, HiSilicon | Observation 1: Without introduction of new channel filters, WiderCHBW might not be applicable for non-collocated scenarios.  Observation 2: To meet the TX emission and RX ACS/blocking, new channel filters are needed for the gNB which is not prioritized as stated in the SID.  Observation 3: If no dedicated channel filter is assumed, the requirements are not clear for the UE with capability to receiver the entire spectrum block. |
| R4-2111147 | Ericsson | Observation 1: For irregular bandwidths between 5 and 10MHz the overlapping UE channel bandwith solution is not preffered since the minimum bandwith of CORESET#0. Hence the method of using immediate wider channel bandwidht is suggested.  Observation 2: A “legacy” UE not indicating ensured support for unwanted emission while blanking will still be able to attach to the NW but be configured with a smaller UE CHBW providing lower SU.  Observation 3: Additional UE Emission requirements might need to be developed (in a possible W.I phase)  Observation 4: The blanking method will need implementation changes for both the NW/base station as well as a UE.  Observation 5: A reduced set of requirements for the irregular bandwidth, only regulatory emissions requirements in UL, are required for irregular bandwidths if next largest standardized bandwidth is supported.  Observation 6: A “Fall back” mode to the next smaller regular BW can be used and handled by NW implementation (deployment or steering of BWP) for scenarios where near-far problem occurs.  Proposal 1: Agree to further extend the wider CHBW (blanking) approach for irregular bandwidths also larger than 10 MHz.  Proposal 2: Agree to define only smaller CHBW used by the UE in UL and further develop the usage of full irregular CHBW in UL in later releases.  Proposal 3: Investigate specification (RAN1, RAN2, RAN4) impact of asymmetric configurated BWP within an operating band that is/is not asymmetric defined.  Proposal 4: Agree to further develop the “immediate wider channel bandwidth” method (a.k.a blanking) for irregular BW’s between 5 and 10MHz. Since this method provides highest possible SU, less complaxity on BS (and possibly UE), shared implementation burden between NW and UE.  Proposal 5: Adding UE capability/capabilities that indicate the UEs support for irregular bandwidths if to be supported in UL. |
| R4-2111148 | Ericsson | Draft TP to TR38.844 on wider channel BW method  *Moderator: Comments on specifics for the TP should be captured in Section 2.3.2* |
| R4-2109245 | Intel Inc | Proposal 2: Use the WiderCBW method for irregular CBW < 10MHz. |
| R4-2109435 | Apple | TP on using next larger channel bandwidth solution  *Moderator: Comments on specifics for the TP should be captured in Section 2.3.2* |

## Open issues summary

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

* + 1. Sub-topic 2-1

General aspects such as applicibility of widerCHBW approach and DL/UL

**Issue 2-1: Applicability of widerCBW approach**

* Proposals
  + Option 1: Use the WiderCBW method for irregular CBW < 10MHz only
  + Option 2: Apply the WiderCBW method as a general approach for all irregular CBWs
* Recommended WF
  + TBA

**Issue 2-2: irregularBW in UL**

* Proposals
  + Option 1: Adding UE capability/capabilities that indicate the UEs support for irregular bandwidths if to be supported in UL.
  + Option 2: Agree to define only smaller CHBW used by the UE in UL and further develop the usage of full irregular CHBW in UL in later releases.
* Recommended WF
  + WF (R4-2103263) Agreement on DL only shall be upheld. Option 3 should be discussed for DL (widerCHBW) and UL (smallerCHBW) where the DL utilizes irregularBW. To support UL for irregularBW in future releases is FFS.

**Issue 2-3:Asymmetric Configured BWP**

* Proposals
  + Option 1: Investigate specification (RAN1, RAN2, RAN4) impact of asymmetric configurated BWP within an operating band that is/is not asymmetric defined.
  + Option 2: No impact to specification (RAN1, RAN2, RAN4) with respect to asymmetric configured BWP
* Recommended WF
  + TBA
    1. Sub-topic 2-2

BS TX requirements.

**Issue 2-3: BS TX Emissions**

* Proposals
  + Option 1: new TX emissions mask needs to be defined associated with a certain number of blanked PRBs for the use of WiderCBW
  + Option 2: no new requirements are needed
* Recommended WF
  + gNB TX emissions requirements are needed for irregularBW definition due to regulatory requirements
    1. Sub-topic 2-3

UE RX requirements. .

**Issue 2-4: UE RX ACS/Blocking**

* Proposals
  + Option 1: “Fall back” mode can be applied therefore no specific UE ACS/blocking for irregularBW is needed
  + Option 2: new UE RX ACS/blocking requirement needs to be defined
  + Option 3: UE RX ACS/blocking is not an issue.
* Recommended WF
  + TBA

**Issue 2-5: UE REFSENS**

* Proposals
  + Option 1: new REFSENS needs to be defined associated with a certain number of blanked PRBs for the use of WiderCBW
  + Option 2: no new REFSENS requirements are needed
* Recommended WF
  + TBA

**Issue 2-6: UE Filter**

* Proposals
  + Option 1: no dedicated channel filter is assumed for irregularBW only widerCHBW is needed
  + Option 2: dedicated channel filter is required for irregularBW
* Recommended WF
  + TBA

## Companies views’ collection for 1st round

## Open issues

Sub topic 2-1

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| --- | --- |
| **Company** | **Comments** |
| Intel | Issue 2.1 Applicability of WiderCBW Approach  Option 1 – Use WiderCBW < 10MHz and Overlapping BW for > 10MHz. The WiderCBW approach is weaker with degraded ACS / reduced REFSENSE and should not be used above 10MHz as there are better solutions.  Issue 2.2 IrregularBW in UL  Agree with WF. UL FFS only.  Issue 2.3 Asymmetric Configured BWP  Not clear that asymmetric BWP needed |
| Skyworks | Issue 2.1: Option 2, WiderCBW can be a genric approach at least in DL, also it can be compatible with the overlap of smallerCBW from network point of view  Issue 2.2: widerCBW may be usable in UL but SU may be less aggressive in UL to provide larger guard bands and ensure that regulatory emissions can be supported. Also the scheduler could allocate RBs only within the smallerCBW for the upper range of output power. At this point this should be an optional UE capability especially if additional UL test/A-MPR requirements are needed. |
| Ericsson | Issue 2-1: WiderCBW approach can be applicable for all irregularBWs  Issue 2-2: Prioritize for DL as per WF. UL is feasible with WiderCBW approach and could be studied at a later stage.  Issue 2-3: For DL as irregularBW and UL in smallerCHBW this is asymmetric and is supported by specifications. Band specific requirements. |
| ZTE | Issue 2.1 Applicability of WiderCBW Approach  Option 1. We cannot conclude a generic principle applicable to all irregular bandwidths without sufficient study.  Issue 2.2 IrregularBW in UL  We are fine with the WF.  For Option 1, a UE supports IrregularBW in UL via WiderCBW approach, and if the WiderCBW is mandatory for the UE, then there is no capability needed, and otherwise if WiderCBW is optional, then there is already a signaling indicating its support. So in any case, no new capability signaling is needed.  Issue 2.3 Asymmetric Configured BWP  Our understanding is Option 2.  In current specs, DL BWP and UL BWP are configured separately, implying that asymmetric configured BWP is already supported. |
| Qualcomm | Issue 2-1:  Option 2. this should be conditioned on using the approach in the first place which we do not actually think it is a good idea. our preference would be not to employ this method at all.  Issue 2-2:  WE agree with the recommended WF  Issue 2-3:  Option 1. even though this asymmetric configured channel BW is used in some bands, implications should be studied. Also, increase in testing burden should be considered. |
| Nokia | In general, there are still many open issues for this method which need to be evaluated first. It should be clarified how many PRBs need to be blanked for BS (to verify SU efficiency) to meet co-existence and emissions requirements assuming no new gNB channel filters are used. Furthermore, UE co-existence need to be addressed for blanked part (e.g. interfering signal rejection) of the spectrum which is used by other operator. Would it require new UE capability with flexible filter to address issues on Rx co-existence?  Issue 2-2: Option 3 needs to be further clarified. What would be the Tx-Rx separation, would new UE capability be needed for DL due to variable duplex?  Issue 2-3: Impact to be checked by RAN1/2. |

Sub topic 2-2

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| **Company** | **Comments** |
| Intel | Issue 2-3 BS Tx Emissions  the existing Tx emissions masks are sufficient and must still be met. No need to define additional masks for every single irregularBW combination. |
| Huawei | Option2.  Support of UL will need to define new filter and associated RF requirements. |
| Ericsson | Option 2 |
| ZTE | Issue 2-3 BS TX Emissions  Option 2. Blanked PRBs are actually within the filter bandwidth, thus its “in-band emission” level should be less than the regulatory requirements for the “blanked frequency trunk” immediately outside the irregular bandwidth, so no new requirements are needed. |
| Qualcomm | Issue 2-3:  Option 2. Our understanding is that if Option 1 is chosen, then this is equivalent to defining a new channel BW so the method would fall under a different category. |
| Nokia | Option 2 is not clear, does it mean to apply existing requirements? How about the transmission BW and the minimum guard band? |

Sub topic 2-3

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| **Company** | **Comments** |
| Intel | Issue 2-4 UE RX ACS/Blocking  ACS / blocking is certainly an issue.  Issue 2-5 UE REFSENS  Possibly need REFSENS spec to clearly indicate the potential reduction in sensitivity due to lack of filter coverage in BW with blanked PRBs  Issue 2-6 UE Filter  No dedicated channel filter should be required as this becomes an overly complicated requirement for hardware to support each newly introduced mode. A key premise of the WiderCHBW approach is to re-use existing hardware |
| Huawei | For the wider CBW approach, the baseline question should be clarified that whether dedicated channel filter is assumed for the irregularBW? What is the granularity |
| Skyworks | Issue 2-4:Option 1 we do not want specific requirements for all possible irregular BW. the existence of smallerCBW fallback should be used to “escape” problematic cease for WiderCBW  Issue 2-5: Specific REFSENS is not needed: REFSENS can be measured with widerCBW fully allocated (if it fits in the band) and performance known from scaling and UL should be configured with smallerCBW. If widerCBW does not “fit” in the band, smallerCBW REFSENS is measured and scalled.  Issue 2-6: no dedicated channel filter should be assumed |
| Ericsson | Issue 2-4: Fall back mode can be applied  Issue 2-5: Support Option 2. For example if 5 MHz REFSENS is met and 10 MHz for the irregularBW of 7 MHz then this would provide sufficient coverage.  Issue 2-6: Support Option 1. |
| ZTE | Issue 2-4 UE RX ACS/Blocking  Option 2. Interference from the actual user of the blanked PRBs will impact UE Rx ACS/Blocking, and REFSENS.  Issue 2-5 UE REFSENS  Option 1. As seen in the above.  Issue 2-6 UE Filter  Option 1 as stated in the SID. |
| Qualcomm | Issue 2-4:  Option 1. our understanding of this method is that there would be no impact to specs/design and a wider channel BW would be configured. Option 2 would actually mean that we are defining a new channel BW.  Issue 2-5:  Opiton 1. see also our previous commentary. there should be no spec impact form this scheme  Issue 2-6:  Option 1. if Option 2 is chosen, this means defining a new CHBW. |
| Nokia | Issue 2-4: Operator deployments are not necessarily coordinated with each other. Option 1 works only if the adjacent channel is used by the same operator. For option 2, co-existence solution needs to be addressed. Option 3: definitely this is an issue.  Issue 2-5: Option 1 – it is not a REFSENS but blocking issue.  Issue 2-6: None of two options work, option 1 ignores the co-existence issues (ACS/blocking), option 2 is against the purpose of using wider regular channel BW. |

## CRs/TPs comments collection

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

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| **CR/TP number** | **Comments collection** |
| R4-2111148 | Company A |
| Company B |
|  |
| R4-2109435 | Ericsson: Strive for merging with R4-2111148 during meeting week. |
| Company B |
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## 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*

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

## Discussion on 2nd round (if applicable)

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

# Topic #3: Evaluation of use of overlapping UE channel bandwidths

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

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2109245 | Intel Inc | Observation 1: For all CBW > 10MHz, the minimum overlap always exceeds 5MHz, so there is sufficient overlap for the SSB on any Sync raster and CoreSet0.  Observation 2: It is worth noting that the Overlapping carrier approach for CBW > 10MHz, can be implemented with no hardware changes to existing NR compliant UEs.  Observation 3: All of the proposed methods represent a significant SU improvement compared to Legacy mode SU and the difference is small. Other factors such as hardware feasiblity should take precedent over optimizing the last 1% SU.  Observation 4: It is better to pursue solutions with RB-alignment between the two CCs since the SU benefit of No-RB alignment is minimal, 0.6% on average.  Proposal 1: Utilize the Overlapping carrier methods with RB-alignment and 100kHz raster alignment between the two carriers for new irregular CBW > 10MHz. |
| R4-2109426 | ZTE Wistron Telecom AB | Observation 1: Non-aligned PRB grid may result in up to 11 subcarriers loss and even more for the case of PRB bundling.  Observation 2: A UE supporting DL overlapping CA is required to support asymmetric UL and DL channel bandwidth for the concerned band.  Observation 3: For combined UE channel bandwidth, legacy UEs are either restricted to use only one of frequency trunks, or to suffer from a potential NBC issue, and asymmetric UL and DL channel bandwidth support may be required for new UEs.  Observation 4: For overlapping UE channel bandwidth from network perspective, legacy UEs are either restricted to use only one of frequency trunks, or to suffer from a potential NBC issue.  Proposal 1: PRBs from overlapped CCs should be aligned in order to avoid unnecessary resource loss.  Proposal 2: Asymmetric UL and DL channel bandwidth support should be enabled accordingly in the specs for the band where only DL overlapping CA is operating. |
| R4-2109484 | CMCC | Observation 1: Option 3 (Overlapping UE CBW) cannot achieve 90% spectrum utilization of irregular bandwidth from UE perspective and requires new gNB irregular bandwidths.  Observation 2: Compared to option 2 (Combined UE CBW), option1 (Overlapping CA) provides more flexibility on SSB configurations and allows legacy UEs operate on both carriers.  Observation 3: Except for the UE capabilities, no RAN1/2 impacts are foreseen for option1 (Overlapping CA) and option 2 (Combined UE CBW).  Proposal: it is proposed to consider option1 (Overlapping CA) as baseline, and further study option 2 (Combined UE CBW). |
| R4-2109579 | Qualcomm Incorporated | Based on our analysis, the scheme “combined UE CBW” proposed in [2] has the following issues:  - RAN1/2 impact on spec changes and behavior clarifications  - RAN4 impact on spec changes to clarify requirements and possible behavior  - RAN4 impact on performance requirements  - UE implementation complexity  - New UE performance tests and interop testing |
| R4-2110488 | Ericsson | Overlapping CA Approach requires the largest amount of implementation complexity and only RAN2 UE capability signalling is required  For Combined UE Channel Approach an extensive change is required for RAN2 (TS 38.331) for UE to differentiate the need to union the additional PRBs with the main carrier described in SIB1.  Overlapping UE Channel Bandwidth approach provides minimal specification changes |
| R4-2110662 | Huawei, HiSilicon | Observation 1: for channel bandwidths less than 50 MHz, integer-multiples of 5MHz channel bandwidths are supported/will be supported in BS/UE specifications.  Proposal 1: New dedicated channel bandwidths are not considered for both BS and UE.  Observation 2: The configuration of SSB can be left to network and no specification impact is needed.  Observation 3: The impact to RF core requirements is very limited to support overlapping CA.  Observation 4: there is no impact on RAN1 and RAN2 of intra-band overlapping CA to support the irregular channel bandwidth except for UE capability signalling. |
| R4-2111219 | Nokia, Nokia Shanghai Bell | Proposal 1: In order to maximize the spectrum utilization while keeping the PRB grid alignment between the main and the additional RF carrier, an alignment of the additional RF carrier with the 100 kHz channel raster is not required.  Observation 1: The proposed method does not have impact to existing RAN2 signalling or to RAN1 specifications. RAN4 may consider LS to RAN1/2 to confirm this observation.  Proposal 2: The study of overlapping channel bandwidths from UE perspective, according to objective 3 of the SID, shall include an approach with a single carrier from baseband perspective, allowing for a single BWP to cover the combined channel bandwidths in RRC\_CONNECTED.  Proposal 3: The PRB grid alignment is mandatory among overlapping channel bandwidths.  Observation 2: Overlapping carriers with two SSBs are less spectrum efficient due to redundant radio resource allocations for common channels and signals. Furthermore, the scheduling of those resources is complicated.  Proposal 4: For spectrum efficiency, solutions with only a single SSB are considered with higher priority than solutions needing a second SSB. Feedback from operators is desired on whether it is sufficient to serve all legacy UEs on the same side of a spectrum block if it is smaller than 10 MHz (e.g. in the main RF carrier's 5 MHz on the left-hand side of figure 2).  Proposal 5: It is proposed to agree on the text proposal below  *Moderator: Comments on specifics for the TP should be captured in Section 3.3.2* |
| R4-2109587 | Qualcomm Incorporated | Comparison of Different Schemes |
| R4-2109436 | Apple, Ericsson, Skyworks Solutions Inc. | TP on using overlapping channels from the network perspective solution  *Moderator: Comments on specifics for the TP should be captured in Section 3.3.2* |

## Open issues summary

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

Each sub-topic is divided to capture the discussion on each approach for overlapping. First issue will be used to capture the feasibility issues (if any). Second issue will be related to specification changes needed to facility the approach (either RAN1, 2 or 4 specs). Third issue will be used to capture the benefits, draw backs and implementation complexities. Headings for each approach description (and their reference) is taken from R4-2105419, “Way forward on Evaluation of IrregularBW Approaches” also R4-2105419 is used as a basis for comparison in this meeting. **Please provide your comments on each “Approach aspect” and if it is not correct assessment of the approach please indicate why.**

* + 1. Sub-topic 3-1

Sub-topic description: Overlapping CA (two cells) (R4-2106486)

**Sub-topic 3-1 Issue 3-1: Feasibility**

* Proposals
  + Approach aspect 1: Legacy UE can operate in either carrier if two SSBs are configured.
  + Approach aspect 2: UE perspective, overlapping channels supported in DL only
  + Approach aspect 3: RB alignment is needed (without alignment there is no spectral efficiency gain)
  + Approach aspect 4: UE testing for irregularBW is needed. The CA framework can be reused.

**Sub- topic 3-1 Issue 3-2: Specification impacts (RAN1, 2, and/or 4)**

* Proposals
  + Approach aspect 1: UE capability of supporting overlapping CA is needed. New feature introduction.
  + Approach aspect 2: Define CA combinations (irregularBW + regular NR BW)
  + Approach aspect 3: Clarify which/how CA requirements apply in this case (channel spacing, emissions, etc.)

**Sub- topic 3-1 Issue 3-3: Benefits, draw backs and implementation complexities**

* Proposals
  + Approach aspect 1: No new channel filters for UE is needed. No new UE CBW is needed
  + Approach aspect 2: No new gNB CBW is required. Need further check how the regulatory requirements should be defined
  + Approach aspect 3: Asymmetric UL and DL channel bandwidth support should be enabled accordingly in the specs for the band where only DL overlapping CA is operating.
    1. Sub-topic 3-2

Sub-topic description: Combined UE CBW (One cell) (R4-2107040)

**Sub- topic 3-2 Issue 3-1: Feasibility**

* Proposals
  + Approach aspect 1: from UE perspective, overlapping channels supported in DL only
  + Approach aspect 2: Legacy UE would operate in smallerCHBW carrier

**Sub- topic 3-2 Issue 3-2: Specification impacts (RAN1, 2, and/or 4)**

* Proposals
  + Approach aspect 1: network will broadcast smallerCHBW in SIB1 and reconfigure UEs supporting this feature in connected mode to use wider BWP (to cover combined channel bandwidths)
  + Approach aspect 2: Impact to RAN1 and RAN2 to change the BWP constraints and clarify UE configuration/behavior with the new channel and BWP configuration.
  + Approach aspect 3: no change to RAN1 and RAN2 existing signalling
  + Approach aspect 4: New UE capability signaling needed
  + Approach aspect 5: BS requirement clarification needed main and additional RF carrier would re-use existing RF requirements

**Sub- topic 3-2 Issue 3-3: Benefits, draw backs and implementation complexities**

* Proposals
  + Approach aspect 1: if UEs handle two carriers in separate FFT, then this will be similar with “overlapping CA” approach from UE perspective.
  + Approach aspect 2: No new gNB CBW is required. Need further check how the regulatory requirements should be defined.
  + Approach aspect 4: Increased implementation complexity at BS and UE
  + Approach aspect 5: new RAN4 performance requirements needed
  + Approach aspect 6: Solution can be applied to any bandwidth
    1. Sub-topic 3-3

Sub-topic description: Overlapping UE CBW from network perspective (One cell) (R4-2106689) (R4-2104887)

**Sub-topic 3-3 Issue 3-1: Feasibility**

* Proposals
  + Approach aspect 1: Only the smallerCHBW is used for DL and UL.
  + Approach aspect 2: No change is needed from UE perspective.

**Sub- topic 3-3 Issue 3-2: Specification impacts (RAN1, 2, and/or 4)**

* Proposals
  + Approach aspect 1: No impacts on other WGs are foreseen.
  + Approach aspect 2: new BS requirements for the irregularBW

**Sub- topic 3-3 Issue 3-3: Benefits, draw backs and implementation complexities**

* Proposals
  + Approach aspect 1: No UE impact, fully backwards compatible
  + Approach aspect 2: Symmetric UL/DL operation
  + Approach aspect 3: Simplest approach however for less than 10 MHz irregularBW complexity increases due to SSB multiplexed in time

## Companies views’ collection for 1st round

* + 1. Open issues

Sub topic 3-1 – Overlapping CA

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| **Company** | **Comments** |
| Intel | Issue 3-1 Feasibility  Aspect – 1,3,4. RB alignment is needed. Legacy UE can operate in either carrier. UE testing can reuse CA framework, FFS  Issue 3-2 Spec Impacts (RAN1, 2, 4)  Aspect – 1, While existing CA structure is mostly sufficient, overlapping CA should be introduced as a new feature and seek buy-in from RAN1, 2  Issue 3-3 Benefits, drawback and implementation complexities  No new channel filters for UE are needed. No new CBW is needed for UE or gNB |
| Huawei | **Feasibility:**  RB alignment is really not a must for CA. It is a subset and can be configured if needed.  **Specification impacts:**   1. IrregularBW should be avoided hence there is no scenario to define irregularBW+regularBW 2. The CA framework can be reused, i.e. with the overlapping CA is configured, it is measured carrier by carrier and the relevant requirement per carrier can be reused.   **Benefits, draw backs and implementation complexities:**  1. the BS out of band requirements are defined according to the edge carrier. Hence the existing requirements can be reused directly for regulatory requirements.  2. No asymmetric UL and DL channel bandwidth support is needed for overlapping CA. It is the same case as the normal 2 DL CA and 1UL. |
| Skyworks | Not our preferred approach, if adopted, some restrictions should apply to make compatible with widerCBW  Issue 3-1 Feasibility: RB alignement is needed and enables overlapping from network prospective that is also compatible with widerCBW. Legacy UE need to be able to operate at least in one of the two channels. Overlapping supported in DL only.  Issue 3-3: No new channel filters for UE are needed. No new CBW is needed for UE |
| Ericsson | Issue 3-1:  Aspect 1: Agree.  Aspect 2: Agree.  Aspect 3: For irregularBW < 10 MHz as example CORESET#0 would need to be TDM anything other than RB alignment would be complex.  Aspect 4: CA framework can be used but CA with irregularBW + regular NR BW would require at least 3 carriers.  Issue 3-2:  Aspect 1: Agree (UE behaviour for overlapping CBW is unpredictable)  Aspect 2: Agree. Since UE capability in Aspect 1 is per CA combination.  Issue 3-3:  Aspect 1: Agree.  Aspect 2: Agree  Aspect 3: Not needed. UL/DL asymmetry is inherently supported by intra-band CA. |
| ZTE | Sub-topic 3-1 Issue 3-1: Feasibility  o Approach aspect 1: Legacy UE can operate in either carrier if two SSBs are configured.  Agree.  o Approach aspect 2: UE perspective, overlapping channels supported in DL only  Agree.  o Approach aspect 3: RB alignment is needed (without alignment there is no spectral efficiency gain)  Agree, otherwise there will be unnecessary spectrum efficiency.  o Approach aspect 4: UE testing for irregularBW is needed. The CA framework can be reused.  Agree.  Sub- topic 3-1 Issue 3-2: Specification impacts (RAN1, 2, and/or 4)  o Approach aspect 1: UE capability of supporting overlapping CA is needed. New feature introduction.  Treating overlapping CA as a new feature is an over-kill since most of core requirements and tests can refer to normal CA.  o Approach aspect 2: Define CA combinations (irregularBW + regular NR BW)  If IrregularBW is not a defined CBW, this approach (Defining CA combos) is not appliable.  o Approach aspect 3: Clarify which/how CA requirements apply in this case (channel spacing, emissions, etc.)  Agree. This would have minimized specs impact.  Sub- topic 3-1 Issue 3-3: Benefits, draw backs and implementation complexities  o Approach aspect 1: No new channel filters for UE is needed. No new UE CBW is needed  This is agreed in the SID.  o Approach aspect 2: No new gNB CBW is required. Need further check how the regulatory requirements should be defined  This is not encouraged in the SID.  o Approach aspect 3: Asymmetric UL and DL channel bandwidth support should be enabled accordingly in the specs for the band where only DL overlapping CA is operating.  Of course single UL CC is supported by default. However, enabling asymmetric UL and DL support with 2 UL CCs can increase UL spectrum usage from UE perspective. |
| Qualcomm | Issue 3-1: Feasibility  Approach aspect 1: Agree  Approach aspect 2: Agree  Approach aspect 3: Agree  Approach aspect 4: Agree. some kind of testing will be needed to check that the UE works as expected  Issue 3-2: Specification impact  Approach aspect 1: Agree  Approach aspect 2: Agree  Approach aspect 3: Agree  Issue 3-3: Benefist, drawbacks and implementation complexities  Approach aspect 1: Agree  Approach aspect 2: Agree  Approach aspect 3: Disagree. our understanding is that the overlapping channels that are aggregated are from the existing set and would be symmetric. |
| Nokia | Issue 3-1: aspect 1: not always possible to have 2 SSBs for <10MHz in the frequency domain  Issue 3-2: aspect 2: new type of CA BW classes would be needed with less than minimum channel spacing, would UEs support every CHBW with 1MHz step or new class for each irregular BW would be needed?  Issue 3-3: aspect 3: would that require additional signalling overhead?  **Specification impact:**  On top of RAN4, impact to RAN1/2 needs to be evaluated, e.g. since CA is considered, there will be BSR per serving cell – how would this be handled when these are overlapped? How does UE report CSI for the overlapped part? What about SRS, can there be SRS carrier switching between the carriers? SCell has either PDCCH or is cross-carrier scheduled, how would that work in overlapping CA case?  **Benefits, draw backs and implementation complexities:**  Peak data rate reduced comparing to sub-topic 3-2 (single cell) due to CA overhead and two SSBs. Without RB alignment SU is further reduced. May require duplicated SSBs/other radio resources which may conflict in frequency domain -> SSB to be transmitted in a staggered manner in time domain which has impact to scheduler complexity. |
| Moderator Summary before GTW (Thursday) | **Sub-topic 3-1 Issue 3-1: Feasibility**   * Proposals   + Approach aspect 1: Legacy UE can operate in either carrier if two SSBs are configured.   + Nokia: not always possible to have 2 SSBs for <10MHz in the frequency domain   + Approach aspect 2: UE perspective, overlapping channels supported in DL only   + Nokia: new type of CA BW classes would be needed with less than minimum channel spacing, would UEs support every CHBW with 1MHz step or new class for each irregular BW would be needed?   + Approach aspect 3: RB alignment is needed (without alignment there is no spectral efficiency gain)   + Huawei: RB alignment is really not a must for CA. It is a subset and can be configured if needed.   + Approach aspect 4: UE testing for irregularBW is needed. The CA framework can be reused.   **Sub- topic 3-1 Issue 3-2: Specification impacts (RAN1, 2, and/or 4)**   * Proposals   + Approach aspect 1: UE capability of supporting overlapping CA is needed. New feature introduction.   + Approach aspect 2: Define CA combinations (irregularBW + regular NR BW)   + Should not support (or N/A)   + Approach aspect 3: Clarify which/how CA requirements apply in this case (channel spacing, emissions, etc.)   Nokia: How does UE report CSI for the overlapped part? What about SRS, can there be SRS carrier switching between the carriers? SCell has either PDCCH or is cross-carrier scheduled, how would that work in overlapping CA case?  **Sub- topic 3-1 Issue 3-3: Benefits, draw backs and implementation complexities**   * Proposals   + Approach aspect 1: No new channel filters for UE is needed. No new UE CBW is needed   + Approach aspect 2: No new gNB CBW is required. Need further check how the regulatory requirements should be defined   + Huawei: BS out of band requirements are defined according to the edge carrier   + Approach aspect 3: Asymmetric UL and DL channel bandwidth support should be enabled accordingly in the specs for the band where only DL overlapping CA is operating.   + Different company understandings on symmetry of DL/UL |

Sub topic 3-2 – Combined UE CBW

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| **Company** | **Comments** |
| Intel | Issue 3-1 Feasibility  Feasibility is unclear to us how this option is intended to work for the UE. Perhaps an additional block diagram showing how UE signal combining might work could be provided  Issue 3-2 Spec Impacts (RAN1, 2, 4)  Issue 3-3 Benefits, drawback and implementation complexities  Aspect 1: without better understanding the proposed block diagram, it appears that the only WF is to use separate FFT for each UE which is similar to “overlappling CA” approach. It is probably not feasible to require UEs to implement a new architecture to support combining spectrum before FFT |
| Huawei | **Specification impacts:**  There is RAN1/RAN2 impact, e.g. the BWP can’t be outside of the resource grid.  **Benefits, draw backs and implementation complexities:**  The major complexity is that the existing implementation is that the baseband channel and RF channel are one to one mapping. Hence the approach with single BB channel mapping to two RF channel will need significant implementation complexities. |
| Skyworks | Not our preferred approach, if adopted, some restrictions should apply to make compatible with widerCBW, Leagcy UE can only use on of the channels  Issue 3-1: only in Dl and legacy UE possible in one channel only |
| Ericsson | Issue 3-1:  Aspect 1: Not feasible since the cell-specific carrierBandwidth cannot be changed in dedicated signaling (ServingCellConfigCommon). A BWP cannot be configured outside the carrierBandwidth. However, a UE dedicated BW (location of RF filter) can be configured outside the carrierBandwidth  Aspect 2: Agree.  Issue 3-2:  Major change to RAN2 spec. |
| ZTE | Sub- topic 3-2 Issue 3-1: Feasibility  o Approach aspect 1: from UE perspective, overlapping channels supported in DL only  Agree as an previous agreement.  o Approach aspect 2: Legacy UE would operate in smallerCHBW carrier  Agree.  Sub- topic 3-2 Issue 3-2: Specification impacts (RAN1, 2, and/or 4)  o Approach aspect 1: network will broadcast smallerCHBW in SIB1 and reconfigure UEs supporting this feature in connected mode to use wider BWP (to cover combined channel bandwidths)  Reconfigured DL BWP after connection should be restricted within the broadcast BS channel bandwidth.  o Approach aspect 2: Impact to RAN1 and RAN2 to change the BWP constraints and clarify UE configuration/behavior with the new channel and BWP configuration.  Yes agree.  o Approach aspect 3: no change to RAN1 and RAN2 existing signalling  No, RAN1/RAN2 change is needed.  o Approach aspect 3: New UE capability signaling needed  Needs to check further.  o Approach aspect 4: BS requirement clarification needed main and additional RF carrier would re-use existing RF requirements  Agree.  Sub- topic 3-2 Issue 3-3: Benefits, draw backs and implementation complexities  o Approach aspect 1: if UEs handle two carriers in separate FFT, then this will be similar with “overlapping CA” approach from UE perspective.  Agree.  o Approach aspect 2: No new gNB CBW is required. Need further check how the regulatory requirements should be defined.  Agree. |
| Qualcomm | Issue 3-1: Feasibility  Approach aspect 1: Agree.However, implementation is difficult  Approach aspect 2: Agree.However, all legacy UEs would have to be in the same spectrum chunk.  Issue 3-2: Specification impact(RAN1,2, and/or 4)  Approach aspect 1: Agree  Approach aspect 2: Agree  Approach aspect 3: Basically agree. However, this would have to be checked by RAN1 and RAN2 to make sure.  Approach aspect 4: Agree  Approach aspect 5: Agree. there might be other impications also that cannot be assessed now before the method is fully understood  Issue 3-3: Benefits, draw backs and implementation complexities  Approach aspect 1: Disagree. the UE processing on the baseband physical layer is totally different compared to CA. CA works independently(separate codewords, HARQ processes, etc). this method implies processing the 2 chunks together as a single channel.  Approach aspect 2: Agree  Approach aspect 4: Agree  Approach aspect 5: agree  Approach aspect 6: Agree |
| Nokia | Issue 3-2: aspect 2: there is no impact to RAN1 and existing RAN2 signalling (both BWP and CHBW (UE specific) are reconfigured for some UEs in connected mode), details are provided in R4-2111219. Aspect 4: similar changes are expected as for sub-topic 3-1 (based on non-contiguous intra-band CA but without the gap).  **Specification impacts:**  No impact to RAN1 and existing RAN2 signalling. Limited impact to RAN4 since most requirements are re-used to guarantee co-existence.  **Benefits, draw backs and implementation complexities:**  Highest SU for both gNB and UE with one SSB only and no CA overhead.  Future proof solution, solution can be applied to any spectrum block.  No additional channel filters for UE and gNB.  Increased complexity but this applies to other methods as well. |
| Moderator Summary before GTW (Thursday) | **Sub- topic 3-2 Issue 3-1: Feasibility**   * Proposals   + Approach aspect 1: from UE perspective, overlapping channels supported in DL only   + Approach aspect 2: Legacy UE would operate in smallerCHBW carrier   + Qualcomm: all legacy UEs would have to be in the same spectrum chunk   + Skyworks: UE possible in one channel only   **Sub- topic 3-2 Issue 3-2: Specification impacts (RAN1, 2, and/or 4)**   * Proposals   + Approach aspect 1: network will broadcast smallerCHBW in SIB1 and reconfigure UEs supporting this feature in connected mode to use wider BWP (to cover combined channel bandwidths)   + Approach aspect 2: Impact to RAN1 and RAN2 to change the BWP constraints and clarify UE configuration/behavior with the new channel and BWP configuration.   + Approach aspect 3: no change to RAN1 and RAN2 existing signalling   + Approach aspect 4: New UE capability signaling needed   + Approach aspect 5: BS requirement clarification needed main and additional RF carrier would re-use existing RF requirements   Moderator: seems different understanding on if RAN1/2 spec impact. Different understanding on whether RAN1/2 spec needs changing.  **Sub- topic 3-2 Issue 3-3: Benefits, draw backs and implementation complexities**   * Proposals   + Approach aspect 1: if UEs handle two carriers in separate FFT, then this will be similar with “overlapping CA” approach from UE perspective. * Qualcomm: Disagree. the UE processing on the baseband physical layer is totally different compared to CA. CA works independently(separate codewords, HARQ processes, etc). this method implies processing the 2 chunks together as a single channel.   + Approach aspect 2: No new gNB CBW is required. Need further check how the regulatory requirements should be defined.   + Approach aspect 4: Increased implementation complexity at BS and UE   + Approach aspect 5: new RAN4 performance requirements needed   + Approach aspect 6: Solution can be applied to any bandwidth |

Sub topic 3-3 – Overlapping UE CBW from network perspective

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| **Company** | **Comments** |
| Intel | Issue 3-1 Feasibility  Approach 2, No hardware change should be required  Issue 3-2 Spec Impacts (RAN1, 2, 4)  Ideally, minimal impacts on other WGs for CBW > 10MHz. Inevitably there will be some signaling changes or notifications required  Issue 3-3 Benefits, drawback and implementation complexities  This solution is feasible for >10MHz because there are no required changes in SSB timing. For < 10MHz, the required additional modes for time staggered SSBs is likely too complex and would require significant updates to the SSB methodology from RAN1, 2 |
| Huawei | **Benefits, draw backs and implementation complexities**   1. New BS channel bandwidths are needed which is not prioritized as stated in the SID. 2. Only smaller channel bandwidth is used for UE |
| Skyworks | Prefered approach as simple and compatible with widerCBW.  Issue 3-1: easiest support with legacy UEs but not limited to smallerCBW as it is compatible with wideCBW.  Together with widerCBW is supports all BW (below and abve 10MHz) with minimum changes at UE and BS. |
| Ericsson | Issue 3-1:  Agree to both Aspect 1 and 2.  Issue 3-2:  Aspect 1: Agree.  Aspect 2: Minimum set of (regulatory) requires are needed.  Issue 3-3:  Aspect 1: Agree  Aspect 2: Agree.  Aspect 3: Agree. It would be good to consider this approach only for > 10 MHz irregularBW |
| ZTE | Sub-topic 3-3 Issue 3-1: Feasibility  o Approach aspect 1: Only the smallerCHBW is used for DL and UL.  Agree.  o Approach aspect 2: No change is needed from UE perspective.  Agree.  Sub- topic 3-3 Issue 3-2: Specification impacts (RAN1, 2, and/or 4)  o Approach aspect 1: No impacts on other WGs are foreseen.  Agree.  o Approach aspect 2: new BS requirements for the irregularBW  Agree.  Sub- topic 3-3 Issue 3-3: Benefits, draw backs and implementation complexities  o Approach aspect 1: No UE impact, fully backwards compatible  Agree.  o Approach aspect 2: Symmetric UL/DL operation  Agree from UE perspective.  o Approach aspect 3: Simplest approach however for less than 10 MHz irregularBW complexity increases due to SSB multiplexed in time  Yes from BS perspective. |
| Qualcomm | Issue 3-1: Feasibility  Approach aspect 1: Agree  Approach aspect 2: Agree  Issue 3-2: Specification impacts  Approach aspect 1: Agree  Approach aspect 2: Agree. the specs can be written in such a way that implementation impact can be minimized and an implementation on the BS sides as proposed for Combined CHBW is possible  Issue 3-3: Benefits, drawbacks  Approach aspect 1: Agree  Approach aspect 2: Agree  Approach aspect 3: Disagree. complexity increases compared to which scheme? overlapping CA has the same issue and even for combined CHBW, in order to be able to put legacy UEs anywhere in the spectrum block, multiple SSBs could be needed. |
| Nokia | This solution is putting all complexity (e.g. may require duplicated SSBs/other radio resources which may conflict in frequency domain -> SSB to be transmitted in a staggered manner in time domain which has impact to scheduler complexity) in BS implementation as there is no UE impact. There is no gain from UE perspective since they would use smaller channel BW. |
| Moderator Summary before GTW (Thursday) | **Sub-topic 3-3 Issue 3-1: Feasibility**   * Proposals   + Approach aspect 1: Only the smallerCHBW is used for DL and UL.   + Approach aspect 2: No change is needed from UE perspective.   **Sub- topic 3-3 Issue 3-2: Specification impacts (RAN1, 2, and/or 4)**   * Proposals   + Approach aspect 1: No impacts on other WGs are foreseen.   + Approach aspect 2: new BS requirements for the irregularBW   + Ericsson, Qualcomm: Minimum set of requirements needed   **Sub- topic 3-3 Issue 3-3: Benefits, draw backs and implementation complexities**   * Proposals   + Approach aspect 1: No UE impact, fully backwards compatible   + Approach aspect 2: Symmetric UL/DL operation   + ZTE: From UE perspective   + Huawei: Only smaller channel bandwidth is used for UE   + Approach aspect 3: Simplest approach however for less than 10 MHz irregularBW complexity increases due to SSB multiplexed in time   + Nokia: This solution is putting all complexity (e.g. may require duplicated SSBs/other radio resources which may conflict in frequency domain -> SSB to be transmitted in a staggered manner in time domain which has impact to scheduler complexity) in BS implementation as there is no UE impact. There is no gain from UE perspective since they would use smaller channel BW.   + Qualcomm: Disagree. complexity increases compared to which scheme? overlapping CA has the same issue and even for combined CHBW, in order to be able to put legacy UEs anywhere in the spectrum block, multiple SSBs could be needed. |

* + 1. CRs/TPs comments collection

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

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| **CR/TP number** | **Comments collection** |
| R4-2111219 | Ericsson: We suggest to copy the table of SU % into the WF of evaluations of approaches to collect tables on SU for each approach into one place.  Clause 6.5 “ no impact to RAN1 and existing RAN2 signalling” is not agreeable based upon discussion in Topic #3 of email summary. |
| Company B |
|  |
| R4-2109436 | Company A |
| Company B |
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## Summary for 1st round

* + 1. 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:* |

* + 1. CRs/TPs

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

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

## Discussion on 2nd round (if applicable)

*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 |
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**Existing tdocs**

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