**3GPP TSG-RAN WG4 Meeting # 98-bis-e R4-210XXXX**

**Electronic Meeting, 12th – 20th April, 2021**

**Agenda item:** 9.2

**Source:** Moderator (Ericsson)

**Title:** Email discussion summary for [98-bis-e][141] 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

Topic #2: Evaluation of Use of Larger Channel Bandwidth

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

# Topic #1: General TR

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2106690 | Ericsson, Nokia, Nokia Shanghai Bell | **Observation:** Current definition of irregular bandwidth is not aligned between agreed WFs [1][2]. Interested companies are encouraged to provide opinon/views on whether “not a multiple of 5 MHz” shall be part of the definition for irregular bandwidth study.  **Irregular bandwidth:** an NR bandwidth that is not a multiple of 5 MHz and is not defined in Rel-17 |

## Open issues summary

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

### Sub-topic 1-1

*Sub-topic description:*

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

**Issue 1-1: Irregular bandwidth definition**

* Proposals
  + Option 1: Update TP (R4-2106690) with Irregular bandwidth definition as: an NR bandwidth that is not a multiple of 5 MHz and is not defined in Rel-17
  + Option 2: Update TP (R4-2106690) Irregular bandwidth shall be defined as: an NR bandwidth that is not defined in Rel-17
  + Option 3: Approve current version of TP (R4-2106690)
  + Note: Additional comments can be captured relating to the TP in Section 1.3.2 that do not pertain to the irregular bandwidth definition discussion
* Recommended WF
  + TBA

## Companies views’ collection for 1st round

### Open issues

*One of the two formats, i.e. either example 1 or 2 can be used by moderators.*

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| --- | --- |
| **Company** | **Comments** |
| DISH | Sub topic 1-1: Option 1 seems ok.  Sub topic 1-2:  ….  Others: |
| ZTE | Option 2 slightly preferred since an operator can anyway request a new CBW in multiple of 5MHz in Rel-17. |
| Huawei | Options 2 is more general and will be ok to us |
| T-Mobile USA | Option 2: It is more general, and the techniques should also apply to 55, 65,etc. MHz |
| Nokia | Option 2, “not a multiple of 5 MHz” is redundant since all defined channel bandwidths are with multiple of 5MHz. |
| OPPO | Option 2 |
| Skyworks | We prefer option 1 as it clarifies for the future also we should consider if it should have an additional criteria to be a multiple of 1MHz |
| Apple | Option 2 is more generic. |
| Qualcomm | Option 1. for Option 2, how is this different than a new BW like 55 MHz, for example? |

### 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** |
| R4-2106690 | ZTE: In A.5 (Overlapping UE CBW from UE perspective), it implies that one UE may have multiple carriers at the same time, which may work either in CA or DC, and in A.6 (Overlapping CA), it partially repeats A.5 when the UE works in CA mode. |
| Huawei: in A.6, both BS and UE can work in overlapping CA mode. |
| Apple:  "Overlapping UE channel BW from UE perspective: network supports the irregular bandwidth while some new UEs support two overlapping (RF) carriers" needs more clarifications. RF carrier is not a common terminology used in our specifications. Furthermore, since there will be one component carrier, we could not help but wonder whether this solution should be classified as "overlapping channels".  Figures in A.x need more updates. Ideally we have to indicate clearly allocated spectrum, configured spectrum, (initial BWP?), and whether one or several component carriers are used. |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

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

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|  | **Status summary** |
| **Sub-topic #1** | *Tentative agreements:*  *Issue 1-1: Agree for Option 2 since majority companies have indicated their preference.*   * + Option 2: Update TP (R4-2106690) Irregular bandwidth shall be defined as: an NR bandwidth that is not defined in Rel-17   *Candidate options:*  *Recommendations for 2nd round: Update TP (R4-2106690) to include irregular bandwidth definition as indicated in Option 2.*  R4-2106690 will be updated to include irregular bandwidth definition as agreed. Any changes regarding updates to figures (Annex) should be provided by companies in second round which have commented above (Section 1.3.2) |

### 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** |
| R4-2106690 | *To be revised* |

## Discussion on 2nd round (if applicable)

# Topic #2: Evaluation of Use of Larger Channel Bandwidth

*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** |
| R4-2104600 | CMCC | Observation 1: The number of usable RBs for a given irrgegularBW should be equal to or smaller than existing immediately lower channel BW.  Observation 2: SSB should be placed on the sync raster and the overlapping frequency between WiderBW and SmallerBW. |
| R4-2104886 | Apple Inc | Observation 1: Using the next smaller channel bandwidth can be acceptable when the difference between the bandwidth of the operator’s spectrum and the next lower channel bandwidth is not large.  Observation 2: Using the next larger channel bandwidth can be acceptable when the difference between the bandwidth of the operator’s spectrum and the next larger channel bandwidth is not large.  Observation 3: If the next larger channel is relatively large, then the overall utilisation becomes lower, which is especially the case for 30kHz SCS.  Observation 4: Using the next larger channel bandwidth require further 3GPP efforts to define number of schedulable RBs and to check ACS with the emission requirements.  Proposal 1: Capture in the SI TR further technical details on how next larger channel solution can be used to support irregular channel bandwidth.  Proposal 2: For the next larger channel solution, RAN WG4 should work further on how to ensure emission and ACS requirements. |
| R4-2106485 | Huawei, HiSilicon | Observation 1: for co-located adjacent channel deployments, widerCHBW in DL is applicable.  Observation 2: for non-collocated adjacent channel deployments, widerCHBW in DL is not applicable.  Observation 3: for co-located adjacent channel deployments, widerCHBW in UL is applicable for BS.  Proposal 1: WiderCHBW is only applicable for co-located adjacent channel deployments, and no new RF requirement is needed |
| R4-2107253 | Skyworks Solutions, Inc. | Proposal 1 on WiderCHBW:  • WiderCHBW alignment and its allocated BWP should be studied depending on the irregular CHBW position in the band  • Dependency of the exact WiderCHBW positioning on the SSB position for the SmallerCHBW used by legacy UE should be studied  • The 11MHz n29 case should be further studied for the best positioning of the 15MHz WiderCHBW. |
| R4-2107328 | T-Mobile USA | Proposal 1: For the next wider channel BW approach, an operator should be able to configure n85 UEs to use the 6 MHz at the bottom of n85 and n12 UEs that don’t support n85 should be able to be configured to use 5 MHz at the bottom of n12.  Proposal 2: RAN4 to incorporate the TP below into TR 38.844. (Company’s comments on TP should be captured in Section 2.3.2 of this email thread) |
| R4-2104587 | Ericsson France S.A.S | Observation 1: For irregular bandwidths between 5 and 10MHz the overlapping UE channel bandwith solution is not possible given the minimum bandwith of CORESET#0. Hence the method of using immediate wider channel bandwidht is suggested.  Observation 2: SU for the blanking approach is equal on both UE and NW side and optimized to the irregular BW.  Observation 3: SU for the overlapping UE CHBW approach will not provide any end user gain for a deployed irregular bandwidth.  Observation 4: 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 5: Additional UE Emission requirements might need to be developed (in a possible WI phase)  Observation 6: The blanking method will need implementation changes for both the NW/base station as well as a UE.  Observation 7: A reduced set of requirements for the irregular bandwidth, only regulatory emissions requirements, are required for irregular bandwidths if next largest standardized bandwidth is supported.  Observation 8: “Fall back” mode to the small regular BW can be used and handled by NW implementation for scenarios where near-far effect has potential problems.  Proposal 1: Agree to further extend the blanking approach for irregular bandwidths also larger than 10 MHz.  Proposal 2: Adding UE capability/capabilities that indicate the UEs support for irregular bandwidths.  Proposal 3: 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 the implementation burden between NW and UE. |

## Open issues summary

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

### Sub-topic 2-1

*Sub-topic description:*

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

**Issue 2-1: WiderCHBW alignment and Allocated BWP placement**

* Proposals
  + Option 1: SSB should be placed on the sync raster and the overlapping frequency between WiderBW and SmallerBW.
  + Option 2: legacy UEs using SmallerCHBW might use the same SSB to access IrregularCHBW
* Recommended WF
  + TBA

### Sub-topic 2-2

*Sub-topic description*

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

**Issue 2-2: Spectrum Utilization of irregularBW**

* Proposals
  + Option 1: UE SU of smallerCHBW (legacy UEs) and BS in UL SU of irregularBW
  + Option 2: SU is equal on both UE and NW side and optimized to the irregular BW.
  + Option 3: SU > 90% only on NW side
  + Option 4: The number of usable RBs for a given irregularBW should be equal to or smaller than existing immediately lower channel BW
    - If not then reconsider irregularBW to be further studied
* Recommended WF
  + TBA

### Sub-topic 2-3

*Sub-topic description: Regulatory Requirements*

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

**Issue 2-3: Near-Far Effects in adjacent channel deployments**

* Proposals
  + Option 1: Emissions requirements for co-located scenarios for BS and the ACS/blocking for UE can be relaxed
  + Option 2: “Fall back” mode to the small regular BW can be used and handled by NW implementation for scenarios where near-far effect has potential problems.
  + Option 3: WiderCHBW is only applicable for co-located adjacent channel deployments, and no new RF requirement is needed
  + Option 4: Assume WiderCHBW guard band used on UE (e.g. 15kHz/6 MHz irregularBW assumes associated guard band for 10 MHz with guard of 312.5 kHz)
  + Option 5: UE receiver will by design not be completely blocked but continue to work, although the ACS performance may be degraded compared to a UE designed for the operator’s spectrum. The degradation due to WiderCHBW approach is a draw back which is tolerable
* Recommended WF
  + TBA

**Issue 2-4: Tx Emissions Mask**

* Proposals
  + Option 1: Emissions requirements for co-located scenarios for BS can be relaxed
  + Option 2: Use existing emissions mask defined for WiderCHBW
  + Option 3: Define new emissions mask for irregularBW
* Recommended WF
  + TBA

**Issue 2-5: UE ACS and Blocking**

* Proposals
  + Option 1: For co-located BS scenarios the ACS/blocking for UE can be relaxed
  + Option 2: WiderCHBW alignment and its allocated BWP depending on the irregular CHBW position in the band prior as input to ACS/blocking requirements
* Recommended WF
  + TBA

## Companies views’ collection for 1st round

### Open issues

Sub topic 2-1

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| **Company** | **Comments** |
| DISH Network | In general, we prefer to list multiple options as methods to use irregular BW’s. While we don’t advocate usage of wider BW’s, we are OK to have them listed as one of the options. The outcome of this study should be something that works for irregular BW’s. If we target to include only one option that is ok for all as the only option, then we are afraid the study would be concluded with no feasible alternatives. |
| ZTE | Option 2. It should be guaranteed that a UE can access to the irregular BW via SmallerCHBW. |
| Huawei | We did not see the dependency between the two options |
| Nokia | Further study is needed regarding SSB placement as discussed in R4-2107253. |
| OPPO | Option 2 |
| Ericsson | Option 2 should be used to ensure UE can search for SSB |
| Skyworks | At least one SSB and smaller BW channel should be available for legacy UEs. As shown in our paper, the wider BW may reuse the same SSB but the wide BW alignment and its allocated BWP may be aligned in different ways to benefit form the RF filter if the irregular BW is at a band edge (which is the case for many of the band/BW that are discussed). We believe this option can be used in complement of other options. |
| Apple | Option1 and Option 2 are not mutually exclusive but are rather complementary to each other. Option 1 makes practical sense to allow both legacy and new UEs. And our understanding is that there can be a single SSB that will be used by both legacy and new UEs to camp on the cell. Please note that there will be no fundamental difference between legacy and new UEs because SSB will anyway broadcast one of the standard NR channel bandwidth that legacy UEs will support. |
| Qualcomm | As a general comment on this method, legacy UEs are not expected to support any BWP size because this is not tested in any way. There will also be a clear additional part to support BWPs of different sizes because of testing, interoperability testing, etc.  For this issue, the options are not mutually exclusive. For Option 1, SmallerBW can be placed in multiple locations relative to the Wider BW. SSB should be placed on the sync raster, there is no point in increasing the number of sync raster entries. |

Sub topic 2-2

Moderator comment: there is type-o corrected with correct Option 4 label

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| **Company** | **Comments** |
| ZTE | Option 3 (>90% at NW side): rom UE perspective, no matter single carrier (SmallCHBW) or multiple carriers (Overlapping CA) is used for irregular BW, the carrier bandwidth is anyway defined in the existing CHBW set, so SU for irregular BW has meanings only at NW side. |
| Nokia | SU shall be at least 90%, otherwise the feature is not attractive. |
| OPPO | Option 3. Same view as ZTE. |
| Ericsson | Option 4: If SU of irregularBW is not >= 90% using WiderCHBW approach then the SmallerCHBW should be used for the irregularBW |
| Skyworks | SU is understood here as the SU at the network level. This may be dictated by both legacy UEs and UEs using widerBW thus wider BW may have a slightly lower SU than the network. |
| Apple | Firstly, these options are not mutually exclusive. It is true that we shall cater for better SU, but in exceptional cases (if any) we may even accept lower SU if it anyway allows an operator to utilise available spectrum resources. Secondly, our general view is that SU is the same at the UE and the network side, but it can be lower at the UE side if e.g. so configured by the network to meet certain requirements by the legacy UEs. |
| Qualcomm | These options are confusing, not clear what is the end SU on the network and UE side. To choose an option, Option 4 is the safest. |

Sub topic 2-3

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| --- | --- |
| **Company** | **Comments** |
| DISH Network | Issue 2-3: None of these options work well at least in US as the irregular BW is in most if not all cases adjacent to other operator. Hence operator has very limited control on co-location.  Issue 2-4: Somehow the regulator requirements must be met; RAN4 should find the most convenient way for that. If the definition of new emission masks for irregular BW can be avoided, good, but are there any alternatives?  Issue 2-5: None of these options work well at least in US as the irregular BW is in most if not all cases adjacent to other operator. Hence operator has very limited control on co-location.  ….  Others: |
| ZTE | Issue 2-3:  Option 2 if considering its simplicity.  Issue 2-4:  Option 3 seems inevitable because it is not clear on what is the minimum requirement for the emission in the gap between irregularBW and WiderCHBW.  Issue 2-5:  Strictly speaking two options listed here are not in parallel. They are talking about different things.  ….  Others: |
| Huawei | Issue 2-3:  Option 3, but the applicable scenario is quite limited.  Issue 2-4:  Option 1, we can check whether it needs new requirement for co-located scenario.  Issue 2-5:  Option 1, we can check whether it needs new requirement for co-located scenario. |
| Nokia | Issue 2-3: Near-Far Effects in adjacent channel deployments  The coexistence shall be ensured for non-collocated deployment with the same ACLR/ACS level as legacy channels, otherwise this feature is useless. The presented options are not providing any coexistence solution.  Issue 2-4: Tx Emissions Mask  The coexistence cannot be ensured with option 1 and 2. That’s why we are proposing to assume the overlapping legacy channel bandwidths so that the filter characteristics follow the smaller legacy channels and the coexistence can be ensured.  Issue 2-5: UE ACS and Blocking  How coexistence would be guaranteed with proposed options? |
| OPPO | **Issue 2-3: Near-Far Effects in adjacent channel deployments**  Option 2, “Fall back” mode to the small regular BW can be used and handled by NW implementation for scenarios where near-far effect has potential problems.  **Issue 2-4: Tx Emissions Mask**  If this relates to regulation requirements, then Option 3 (Define new emissions mask for irregularBW) needs to be defined.  **Issue 2-5: UE ACS and Blocking**  Option 1. For co-located BS scenarios the ACS/blocking for UE can be relaxed |
| Ericsson | **Issue 2-3: Near-Far Effects in adjacent channel deployments**  Support Option 2: “Fall back” mode to the small regular BW can be used and handled by NW implementation for scenarios where near-far effect has potential problems.  **Issue 2-4: Tx Emissions Mask**  A minimum set of BS requirements are needed from regulatory point of view such as TX emissions. Therefore as part of a subset of requirements rather than a full set of requirements (as would be done for NR regular BWs) irregular BWs would require a SEM for each irregular BW. Support Option 3. |
| Skyworks | Issue 2-3: Even if collocated scenario is not the main scenario it can be at least aknowledge that widerBW approach is well suited for this and if near-far issue arises the UE could fall back to smaller BW  For non-collocated scenarios where the irregular BW is at the band edge a shifted widerBW may work well. And some band/BW proposed cases correspond to this.  Issue 2-5: at least in some cases the ACS and blocking may need lower relaxation at band edges. Option2 is worth studying further and corresponding cases identified |
| Apple | Issue 2-4: It is not clear why we will need to define a new emission mask, the existing emission masks usually scale with the available bandwidth. The major concern is that SSB will broadcast the next larger channel bandwidth and we will consider the corresponding mechanisms to ensure that all the emission requirements will be met.  Issue 2-5: Option 1. ACS and blocking requirements can be relaxed at band edges. |
| Qualcomm | Issue 2-3: Options are not mutually exclusive, cannot pick any of them. For Option 5, how to decide if the drawback is tolerable or not? Option 2 is basically another method discussed in the study.  Issue 2-4: Only possible option is 2, others have impact on existing specs.  Issue 2-5: There shouldn’t be any impact to existing specs, if requirements for current channel BW are changed, it’s equivalent to defining a new channel BW. For option 1, how would the UE know in which scenario it is? |

### 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** |
| R4-2107328 | ZTE: Perhaps better to wait until n85 is completed. |
| T-Mobile USA: To ZTE: While we agree that n85 cannot be part of a WI until the n85 WI is complete, we hope that we will be able to document anticipated operator requirements in the SI TR. Because this band has an aspect that is different than any other band, we would like to make sure it is considered |
|  |

## Summary for 1st round

### Open issues

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

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| --- | --- |
|  | **Status summary** |
| **Sub-topic#2-1** | *Tentative agreements: SSB alignment shall consider legacy UE SSB location. SSB placement shall be overlapping between WiderCHBW and SmallerCHBW* |
| **Sub-topic#2-2** | *Tentative agreements: For using WiderCHBW approach IrregularBW SU > 90% on NW side. IrregularBW SU > 90% on UE side* |
| **Sub-topic#2-3** | *Tentative agreements:*  *Continue to discuss further if “Fall back” mode to the smaller regular BW can be used to ensure near-far effects in adjacent channel deployments can be handled.*  *For regulatory requirements discuss further if WiderCHBW or IrregularCHBW shall be used to for TX emissions, UE ACS and blocking.* |

### 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** |
| R4-2107328 | *To be noted* |

## Discussion on 2nd round

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

### Sub-topic 2-1

**Issue 2-3: Near-Far Effects in adjacent channel deployments**

* Proposals
  + Option 1: “Fall back” mode to the small regular BW can be used and handled by NW implementation for scenarios where near-far effect has potential problems.
  + Option 2: Do not consider “Fall back” mode. For companies which disagree with Option 2 please state the reasons why it would not a possible solution to handle potential problems; additionally the potential drawbacks or areas of concern if “fall back” mode is to be used.

**Issue 2-4: Tx Emissions Mask**

* Proposals
  + Option 1: Emissions requirements for co-located scenarios for BS can be relaxed
  + Option 2: Use existing emissions mask defined for WiderCHBW
  + Option 3: Define new emissions mask for irregularBW
* Recommended WF
  + As this is regulatory requirement Option 3 should be considered.

## Companies views’ collection for 2nd round

### Open issues

Issue 2-3

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| --- | --- |
| **Company** | **Comments** |
| Nokia | Again, the coexistence shall be ensured for non-collocated deployment with the same ACLR/ACS level as legacy channels, otherwise this feature is useless. The presented options are not providing any coexistence solution.  What would be the criteria to identify a potential near-far problem? How such behaviour would be tested to guarantee there are no co-existence issues? The coexistence shall be ensured regardless of other operator's network deployment. |
| Qualcomm | How would the network know it needs to go to fallback mode or not? this seems very complicated |

Issue 2-4

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| --- | --- |
| **Company** | **Comments** |
| Nokia | Option 3, note other requirements would need to be defined as well to ensure proper co-existence. |
| Qualcomm | As we commented in the evaluation document, aren’t regulatory requirements defined already for this spectrum block? Option 3 is the only one that considers this. |

## Summary for 2nd round

### Open issues

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

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| --- | --- |
|  | **Status summary** |
| **Sub-topic#2-1** |  |

# 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** |
| R4-2104599 | CMCC | Observation 1: legacy BWP configuration allows configuring a BWP that is not centred on 100KHz channel raster.  Observation 2: If carriers are not centred around a channel raster frequency  • in LTE-NR co-existence scenario, there may be some problem  • in NR only scenario, existing specs only allow carriers centred around channel raster and need to be revisited  Observation 3: Both single SSB and multiple SSBs should be supported for overlapping CBWs. |
| R4-2107253 | Skyworks Solutions, Inc. | Proposal 2 on overlap from network point of view:  • One of the channel shall use SmallerCHBW and use the current SSB and channel raster (legacy UE channel)  • The second channel also uses SmallerCHBW and should be RB aligned with legacy UE channel and should be applicable to UE supporting overlap from network point of view  • UEs supporting WiderCHBW should not be precluded to operate in a network using overlapped channels and should be able to align with the legacy UE channel at least  Proposal 3 on overlap from UE point of view: Unless it can be demonstrated that better DL performance is obtained versus using a BW part of the immediately higher BW as optional UE support, overlap from UE point of view should not be the priority to study. |
| R4-2104707 | Qualcomm Incorporated | Regarding the overlapping CBW for spectrum allocations narrower than 10MHz, it should be possible to serve UEs that are assigned channels anywhere within the spectrum block as this will be a deployment choice.  Regarding the frequency alignment, if a channel is not placed on a valid channel raster position, the UE will most likely not use this channel since it is not certified to work in it. Whether it would be feasible to design a UE that would be able to use such channel, this is possible, however, the system level gains do not justify the added complexity. |
| R4-2104887 | Apple Inc. | Observation 1: Overlapping carriers can utilise the whole spectrum of "non-standard" channels.  Observation 2: To use the full spectrum with overlapping carriers from the network perspective, the network needs to support the full bandwidth, while from the UE perspective existing standard channels can be used.  Observation 3: While overlapping carriers provide good utilisation for 15kHz SCS, this solution becomes less efficient for 30kHz and provides good spectral utilisation only for certain channel bandwidths.  Observation 4: Overlapping carriers from the network perspective do not require any UE side enhancements, and thus approach can be used with any legacy device.  Observation 5: A solution base on overlapping channels (RF carriers) from the UE perspective still assumes a single baseband and a component carrier.  Observation 6: From the system perspective, this approach can be viewed as "the next larger channel" whereupon guard bands from the next smaller channel are assumed.  Observation 7: Overlapping channels from the UE perspective do not provide any noticeable gain over solution based on using "next larger channel".  Proposal: Capture in the SI TR further technical details on how overlapping channels from the network perspective can be used to support irregular channel bandwidth. |
| R4-2106486 | 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 impact to RF core requirements is very limited to support overlapping CA. |
| R4-2106689 | Ericsson | Observation 1: Studying the overlapping CBWs approach needs to take comparison with other approaches for considering additional implementation complexities and system gains.  Observation 2: The SU will be different and “unbalanced” between the NW and a single UE.  Observation 3: RAN4 should consider on a definition on SU for these irregular bandwidth cases.  Proposal 1: Overlapping UE channel bandwidths approach can only be considered for operator block size larger than 10 MHz due to CORESET#0 size. |
| R4-2107040 | 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 as well as to RAN1 specifications.  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.  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). |
| R4-2107319 | ZTE Corporation | Observation 1: PRB grid should be aligned for the overlapping part of the two carriers, so for the current list of bands intended for irregular channel bandwidth, the distance between the channel raster of the two overlapping channels should be a multiple of 900kHz for both SCS 15kHz and 30kHz.  Observation 2: The minimum guard band at one end should be no less than the minimum requirement by the channel bandwidth next to the end.  Observation 3: Symmetric arrangement of the two overlapping channels are preferred, and the channel bandwidth of each overlapped channel is the immediate larger regular channel bandwidth of the half of irregular bandwidth.  Observation 4: For irregular bandwidth less than 10MHz, a 90% SU can be achieved with a symmetric overlapped channels and the channel raster of the overlapping channels are multiples of 900kHz.  Proposal: Take Option 1 for the case where spectrum blocks is less than 10MHz. |
| R4-2107329 | T-Mobile USA | Proposal 1: For the overlapping UE channel bandwidth approach, an operator should be able to configure n85 UEs to use the 5 and/or 6 MHz at the bottom of n85 and n12 UEs that don’t support n85 should be able to be configured to use 5 MHz at the bottom of n12.  Proposal 2: RAN4 to incorporate the TP below into TR 38.844. (Company’s comments on TP should be captured in Section 3.3.2 of this email thread) |

## Open issues summary

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

### Sub-topic 3-1

*Sub-topic description: Alignment between overlapping UE channel bandwidths concerns*

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

**Issue 3-1: Discuss challenges that comes with Alignment of channel raster vs. Alignment of PRB**

* Proposals
  + Option 1: BWP configuration that is centred on 100 kHz channel raster
  + Option 2: PRB alignment
  + Option 3: 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.
* Recommended WF
  + TBA

### Sub-topic 3-2

*Sub-topic description: SSB placement (*R4-2103387, R4-2107040)

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

**Issue 3-2: Discuss SSB placement for overlapping channel bandwidths for spectrum blocks narrower than 10 MHz**

* Proposals
  + Option 1: It is sufficient to serve all UEs (including legacy) that operate only at one CBW of 5 MHz on the same side of the spectrum block.
  + Option 2: Serve UEs that operate only at one CBW of 5 MHz on both sides of the spectrum block – even if this requires the overhead due to redundant radio resource allocations for common channels and signals.
* Recommended WF
  + TBA

### Sub-topic 3-3

*Sub-topic description: Companies are encouraged to comment regarding Overlapping CA approach (Solution 2 in R4-2106486)*

Solution 2: Overlapping CA

Overlapping CA for gNB

Overlapping CA for UE3

UE1: legacy channel bandwidth

UE2: legacy channel bandwidth

*Open issues, pros/cons relating to the method before e-meeting:*

1. Single common SSB where the SSB is only configured for PCell
2. The impact to RF core requirements is very limited to support overlapping CA.
3. RB alignment is not needed only subcarrier alignment is required with channel spacing multiple of 300 kHz
4. Spectral utilization is >= 90% for 15kHz for all irregularBW

### Sub-topic 3-4

*Sub-topic description: Companies are encouraged to comment regarding Overlapping CBW with combined UE CBW (Figure 1 in R4-2107040)*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| UE's 1st channel bandwidth, e.g. 5 MHz | | |  |  |
|  |  | UE's 2nd channel bandwidth, e.g. 5 MHz with 2 MHz offset | | |
| Combined UE channel bandwidth, e.g. 7 MHz | | | | |

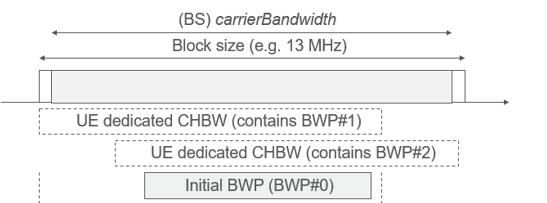
*Open issues, pros/cons relating to the method before e-meeting:*

1. UE’s combined channel bandwidth is equal to irregularBW
2. No impact to RAN2 signaling as well as to RAN1 specifications
3. No additional channel filters need to be designed and tested
4. UEs supporting non-continuous intra-band CA have at least two RF carriers support capability therefore hardware support is already available in downlink

### Sub-topic 3-5

*Sub-topic description: Companies are encouraged to comment regarding Overlapping carriers from the network perspective (Figure 2.1-2 in R4-2104887, Figure 1 in R4-2106689)*





*Open issues, pros/cons relating to the method before e-meeting:*

1. Carriers can be configured on raster points that correspond to the least common multiple of the channel raster and the RB size. (i.e. more flexible options and case-by-case scenarios)
2. UE dedicated CHBW need not be the same
3. Using next larger channel will always provide better performance (compared to overlapping carriers from network perspective) from an individual UE perspective
4. Initial BWP (BWP#0) does not align/fit between overlapping UE CHBWs for < 10 MHz irregularBWs

## Companies views’ collection for 1st round

### Open issues

Sub topic 3-1

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE | Issue 3-1:  Options listed in this issue are not directly comparable.  Others: |
| Huawei | Issue 3-1:  For overlapping CA, the PRB alignment is not needed. While for single BB carrier, the PRB should be aligned. |
| Nokia | Issue 3-1:  Option 3, in order to maximize the spectrum utilization. Alignment of the additional RF carrier with the 100 kHz channel raster would reduce spectrum utilization by up to two RBs for considered scenarios (see R4-2107040). |
| Ericsson | Issue 3-1:  In order for UE to be able to perform initial access SSB need to be placed on 100 kHz channel raster. Support Option 1. Alignment between 2nd UE CHBW (overlapping) it would be up to the approach how this should be handled (PRB or 100 kHz raster) |
| Skyworks | To enable legacy UEs at least one of smallerCHBW should be on the 100KHZ rater and the corresponding SSB raster.  PRB alignment is needed for cases where SSB is in the overlapped region, this is the case for irregular BW <15MHz for wider bW there is only 11RB (<180kHz) to gain. We do not see significant benefit from nor being RB aligned. The main constraint that needs some relaxation would be the intrinsic 900KHz multiple but since we are looking at 1MHz increment this may not be a significant issue. We are fine to further study option 3 at least for overlapping form a network prospective only. |
| Apple | Having the RB alignment is the preferred option. Even though the system can operate in some cases without RB alignment, the actual gains and benefits are not clear. |
| Qualcomm | PRB alignment is clearly needed. Option 1 should talk about channel BW, not BWP. |

Sub topic 3-2

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| **Company** | **Comments** |
| DISH Network | Issue 3-2: Couldn’t we capture both of these as alternatives? Option 2 is very straightforward from UE side and can be supported by Rel-15 devices. Option 2 has it’s Pro’s as well.  ….  Others: |
| ZTE | Issue 3-2:  Option 2. We would expect there is some gain of Option 2 over Option 1.  ….  Others: |
| Huawei | Issue 3-2:  It could be left to network’s choice and both can work. |
| Nokia | Issue 3-2:  Option 1 since Option 2 is less spectrum efficient due to redundant radio resource allocations for common channels and signals. Furthermore, the scheduling of those resources would be complicated (if aggregated channel bandwidth is not large enough (<10 MHz) to carry two non-overlapping SSBs, two SSB transmissions may conflict each other in frequency domain and may be transmitted in a staggered manner in time domain). |
| OPPO | **Issue 3-2: Discuss SSB placement for overlapping channel bandwidths for spectrum blocks narrower than 10 MHz**  Option 2, Serve UEs that operate only at one CBW of 5 MHz on both sides of the spectrum block – even if this requires the overhead due to redundant radio resource allocations for common channels and signals. |
| Ericsson | Issue 3-2:  These options were agreed in last RAN4 meeting in WF R4-2103387 however it doesn’t seem clear to us how serving only one CBW of 5 Mhz would assist in the 7 MHz irregularBW as an example. For the amount of implementation efforts we believe that irregularBW < 10 MHz would require quite extensive coordination on the gNB side for SSB coordination using TDM of SSB rather than the single SSB alignment for irregularBW > 10 MHz for overlapping UE approach. |
| Apple | If and when applicable, one SSB can be used. However, we do not see any issue with having two SSBs either. For small(-er) channel bandwidth they can be staggered in the time domain. And our general understanding is that it will not impact much spectrum utilization because SSB is transmitted periodically. |
| Qualcomm | This can be a deployment choice if specifications will be defined for UEs to work with such new channel location |

Sub topic 3-3

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| **Company** | **Comments** |
| ZTE | Open issues:   1. Single common SSB where the SSB is only configured for PCell   Only PCell is discoverable by UEs, so it could have a heavy access burden.   1. The impact to RF core requirements is very limited to support overlapping CA.   Agree. Only a very few requirements need to be revisited.   1. RB alignment is not needed only subcarrier alignment is required with channel spacing multiple of 300 kHz   Not agreed. Non-aligned PRB in the overlapping parts would result in a potential subcarrier fragments.   1. Spectral utilization is >= 90% for 15kHz for all irregularBW   This can be served as a target for the work in this SID. |
| Huawei | To ZTE on RB alignment, even it may result in subcarrier fragments, the subcarrier alignment can have higher SU as discussed in our paper. |
| Nokia | PRB alignment (together with not required alignment of the additional RF carrier with the 100 kHz channel raster) provides higher SU for 7, 11 and 13MHz spectrum blocks (the same SU is observed for 6 and 12MHz spectrum blocks). Not requiring a PRB alignment could cause a gap of some subcarriers that can neither be used by UEs operating in the lower part nor by those operating in the upper part of the spectrum. Hence not requiring a PRB grid alignment would not increase the cell capacity. |
| Ericsson | To our understanding the “UE1” BW is considered to be PCell and “UE2” is SCell and by means of Carrier Aggregation they are combined into “UE3”. IS this correct understood?  Is the overlapping part scheduled in only one of the cells after a UE is configured with CA? |
| Skyworks | Since it was agreed that RB alignment is needed anyhow for common or non exclusive SSBs we do not see that RB alignment restriction would be a large penalty for the wider BW and could be compatible with wider BW approach and overlapping from NW prospective  Also we are not sure about the overall benefit if many UEs anyhow use smallerBW (like UE1 and UE2) thus that overlap from network point of view is that main feature  It is unclear to us if UE3 in the figure has its RF configured like for a single widerBW channel (1LO) or two smaller BW channels (two LO) in general it would be good that the UE RF and BB configurations are clear for all the overlapping options. |
| Qualcomm | 1. Is the proposal to have SCell without SSB? this is unlikely to work for this case with overlap  2. This is true only for DL  3. RB alignment is needed, there is no advantage to not having alignment as long as there is some overlap in frequency between the channels.  4. this is not true for all scenarios, it would also depend on whether additional raster point can be introduced.  The absolut throughput gain for this scheme is extremely small for a eMBB UE. |

Sub topic 3-4

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| **Company** | **Comments** |
| ZTE | *Open issues, pros/cons relating to the method before e-meeting:*   1. UE’s combined channel bandwidth is equal to irregularBW   Yes, however, we could use an existing term “aggregated CBW”, no need to introduce a new term “UE’s combined CBW”.   1. No impact to RAN2 signaling as well as to RAN1 specifications   Agree.   1. No additional channel filters need to be designed and tested   Agree.   1. UEs supporting non-continuous intra-band CA have at least two RF carriers support capability therefore hardware support is already available in downlink   Agree. |
| Huawei | We do not agree on the statement “an alignment of the additional RF carrier with the 100 kHz channel raster is not required”. The UE is verified with 100 kHz channel raster hence the 100 kHz should be fulfilled. |
| Nokia | On top of benefits of this proposal, also the following is observed:   * future proof solution (not limited to considered spectrum blocks within this SI) * ensured co-existence with very limited impact to RF core requirements (adopt 5/10MHz existing requirements for each overlapping carrier) * SU >=90% * the signalling overhead for the additional RF carrier is small since there is only one carrier from baseband perspective   To Huawei: Not required alignment of the additional RF carrier with the 100 kHz channel raster (together with PRB alignment) provides higher SU. Statement above would apply only to new UEs (which would support this feature) when using additional RF carrier. UEs with 100kHz channel raster would use main carrier. |
| OPPO | Question for clarification:  1. How the 2nd CC is configured to UE via CA or DC? If via the IE *SCS-SpecificCarrier*, not sure whether it is possible to configure the RBs out of CC width.  2. For the overlapping part of two CBW, is it only applied to one CBW rather than two CC?  3. Does UE is required to implement two separate TRx chain to support the whole irregular BW? |
| Nokia | To Oppo:  1. There is one carrier only from baseband perspective.  2. As above, there is one carrier only for new UE from baseband perspective, which is a composite of two RF carriers. The entire bandwidth can be always accessed.  For legacy UE with legacy channel bandwidth, the overlapping part is a part of legacy channel bandwidth.  3. The assumption is UEs which would support this feature have capability of non-contiguous intra-band DL CA. Single Tx chain and two RF Rx chains would be used. |
| Ericsson | It is not possible to configure a BWP that is outside the Carrier Grid.  According to TS38.211, the following is stated “*The starting position and the number of resource blocks in a bandwidth part shall fulfil and , respectively. Configuration of a bandwidth part is described in clause 12 of [5, TS 38.213].*”  It is possible to locate a BWP in a wide region but it cannot be configured. |
| Skyworks | It would help to clarify the underlying UE architecture. How many LO, which channel BW each “carrier” it is configured with….at RF and at BB. |
| Apple | The resulting UE architecture should be further checked. Since this solution assumes that a single baseband component carrier is used, it may impact UE design if several "RF carriers" are attached to the single baseband. In normal CA operation each component carrier effectively corresponds to one baseband and one RF. So, this solution might change the UE design.  As a more general comment, it is generally up to the UE implementation how the RF front end is configured; we are not going to specify RF carriers and how they used by the UE. So, if this solution considers a single component carrier, then it is very close to "using next larger channel" with the only difference that "next smaller channel" guard bands are assumed. The only question is whether a UE can support it, but we do not need to specify how. This is in line with existing specifications when we specify the RF requirements assuming certain guard bands, but we do not specify the RF front end configuration. |
| Qualcomm | 2. It is not clear to us that this proposal has no RAN1 or RAN2 impact, even if the signaling is currently defined. there might changes needed to current procedure and this method is not backwards compatible. From a UE implementation POV, this is similar to overlapping CA but will require additional spec changes.  3. this could be the case but if a single BWP is configured, this will anyway require separate testing.  4. from an RF POV, this resembles intra-band NC CA, however, the support of this feature is very limited for now so it cannot be assumed that this is already supported |
| Nokia | For Ericsson, RAN2 spec is flexible enough to reconfigure the carrier grid in connected mode.  For Apple and Qualcomm, assuming the legacy channel filtering in RF/analog processing would reduce some UE complexity. We could discuss the baseband and signaling aspects if some changes can reduce UE complexity further. |

Sub topic 3-5

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| **Company** | **Comments** |
| DISH Network | Open issue #3 statement is technically confusing. How come it is possible to say that using larger BW is always better from individual UE perspective?  Open issue #4 is irrelevant, as there is a possibility to use 2 SSB’s staggered in time. |
| ZTE | *Open issues, pros/cons relating to the method before e-meeting:*   1. Carriers can be configured on raster points that correspond to the least common multiple of the channel raster and the RB size. (i.e. more flexible options and case-by-case scenarios)   Yes, it can be further elaborated as 900kHz = LCM(100k,180k) for SCS 15kHz.   1. UE dedicated CHBW need not be the same   Agree. However, a symmetric arrangement (i.e., immediate larger CBW of the half irregularBW at each side) could be preferrable.   1. Using next larger channel will always provide better performance (compared to overlapping carriers from network perspective) from an individual UE perspective   Not agreed. It depends on deployment scenarios and size of BWs and UE locations etc.   1. Initial BWP (BWP#0) does not align/fit between overlapping UE CHBWs for < 10 MHz irregularBWs   Yes for BW > 7MHz and less than 10MHz, but for 6MHz, it is possible. |
| Huawei | Issue#1: Overlapping CA do not require RB alignment  Issue#3: it depends. As said the applicable scenarios is quite limited for use of next wider channel bandwidth.  Issue#4: Agree with DISH comments. |
| Nokia | Issue 3: It is challenging to compare it without clarification on WiderCHBW requirements (including internal guard band) to guarantee co-existence with adjacent channels. It has been shown overlapping channel BWs from UE perspective has very high SU thanks to small guard band and signalling overhead for the additional RF carrier.  Issue 4: Agree with Dish. However, solution with two SSBs is less spectrum efficient due to redundant radio resource allocations for common channels and signals. Furthermore, the scheduling of those resources is complicated. |
| Skyworks | From our understanding, the main difference is the 900kHz raster constraint and the fact that overlap is from network only. Which anyhow is a possibility for the the other approaches. With RB alignment, this may also be compatible with widerBW. |
| Apple | For DL, it is generally indeed the case that this solution will result in lower maximum throughput from an individual UE perspective when compared to e.g. "using next larger channel". However, from the overall network and the system performance all RBs can be used. Furthermore, this solution can be even better (1 RB better) because e.g. "using next larger channel" will assume next larger channel guard bands, whereas overlapping channels from the network perspective can use smaller guard bands (please refer to our paper for exact numbers).  For UL, the actual performance will be identical to other solutions that use overlapping channels. In that sense "using next larger channel" will provide better UL performance from an individual UE perspective. |
| Qualcomm | 3. this is not clear, usingl larger channel BW comes with performance penalty because requirements are defined for a larger channel. how is “performance” defined in this case? |

### 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** |
| R4-2107329 | ZTE: Better to wait until n85 is completed. |
| T-Mobile USA: To ZTE: While we agree that n85 cannot be part of a WI until the n85 WI is complete, we hope that we will be able to document anticipated operator requirements in the SI TR. Because this band has an aspect that is different than any other band, we would like to make sure it is considered |
|  |

## 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** |
| **Topic #3** | *Based on chairman’s suggestion in Tues April 13 GTW each approach currently being discussed will be evaluated against the SID objectives. Based on this a possibility to select candidate approaches for further study and focus.*  *Moderator recommends focusing on the Evaluation table for second round.*  *WF on Evaluation of Irregular BW Approaches* |

### 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** |
| R4-2107329 | *To be noted* |

## 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 Evaluation of Irregular BW Approaches | Ericsson |  |
|  |  |  |
|  |  |  |

**Existing tdocs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-2106690 | TP to the TR 38.844: Terminology | Ericsson, Nokia, Nokia Shanghai Bell | Revised | Update with agreed irregular bandwidth definition |
| R4-2107328 | TP for TR 38.844: 6 MHz for n85 with larger CHBW | T-Mobile USA | Noted |  |
| R4-2107329 | TP for TR 38.844: 6 MHz for n85 with overlapping CHBW | T-Mobile USA | Noted |  |
|  |  |  |  |  |

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