**3GPP TSG-RAN4 Meeting #98bis-e *R4-21xxx***

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

**Source:** Ericsson

**Title:** Evaluation of IrregularBW Approaches Against SI Objectives

**Agenda item:** 9.2

**Document for:** Approval

# 1. Summary of Evaluation

*Moderator: Tables of Number of PRBs (wrt SU/system gain discussions) has been included as separate table at the end of this document for visibility*

General Comments:

Qualcomm: for these irregular BWs, how are the regulatory requirements defined? I assume there is some sort of SEM/emission requirement for the entire block(which is irregular). It is not clear if narrower BWs are used (e.g. some overlap technique) that nothing is needed.

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| SI Objective (RP-210706 Clause 4)  | Overlapping CA (two cells)(R4-2106486) | Combined UE CBW (One cell)(R4-2107040) | Overlapping UE CBW (One cell)(R4-2106689)(R4-2104887) | Wider CBW (one cell)(R4-2104587) |
| 1. Identify operator licensed channel bandwidths in FR1 that do not align with existing NR channel bandwidths.
	1. Only licensed spectrum wider than 5 MHz to be considered in this SID.
	2. Spectrum block of 33MHz in n28 require further investigation since there is dual duplexer assumption (2x30MHz) for this band. At RAN4 #98e it was decided to eliminate spectrum block of 33 MHz for n28.
 | N/A | N/A | N/A  | N/A |
| 1. Evaluate the potential use of larger channel bandwidths than operator licensed bandwidth, including the impacts on regulatory emission requirements/UE output power implications and UE ACS/blocking impacts depending on the guard band and the SCS.
 | N/A | N/A | N/A | -[Ericsson]: A “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.-[Huawei, Nokia]: How does “fall back” mode work?-Tx (BS/UE) SEM needs definition for irregularBW-[Apple]: no new SEM is needed -[Nokia]: Not only Tx SEM but other requirements (ACLR/ACS, etc.) as well to guarantee co-existence-[Apple]: Equal UL/DL SU from both the UE and NW perspective |
| 1. Study the use of overlapping UE channel bandwidths (from both UE and network perspective) to cover operator’s license spectrum for both UL and DL, and if new gNB channel bandwidths are needed.

NOTE: For all considered solutions, new (dedicated) channel filters (e.g. non-integer-multiples of 5MHz) are not considered for the UE and not prioritized for the gNB. | -[Huawei]: BS define overlapping CA to cover irregularBW -[Huawei]: For UE, significant implementation effort, especially for UL -[Huawei]: For UE, overlapping CA is optional support in DL only.-new gNB CBW is not required | - adopt 5/10MHz existing requirements for each overlapping carrier to ensure co-existence-[Nokia]:from UE perspective, overlapping channels supported in DL only- [Apple]: from the UE perspective, quite noticeable implementation efforts and potentially changes in the internal design -[Nokia]: does not require new channel filters for UE and gNB-[Nokia]: The carrier is split into 2 phase-aligned RF carriers on the TX side. On the RX side, to ensure phase continuity the phases can easily be aligned by comparing the phases of the RF carriers' overlapping REs. | -DL/UL of UE smallerCHBW only-gNB define irregularBW for regulatory requirements | N/A |
| 1. Identify operator licensed bandwidths that are not compatible with the use of techniques like overlapping UE channel bandwidths. Every proposed method shall be summarized with respect to whether all considered spectrum scenarios are supported or whether there are specific limitations. Some limitations for a specific method shall not disqualify such method if there is a trade-off between flexibility and implementation challenges.
 | From network perspective, SU >= 90%UE smallerCHBW SU >=90% | BS IrregularBW SU >=90%UE IrregularBW SU in DL >=90%UE smallerCHBW SU in UL >=90% | UE smallerCHBW SU >= 90 %BS IrregularCHBW SU>= 90% | UE smallerCHBW SU >= 90 %BS IrregularCHBW SU >= 90%-[Nokia]: It is not clear how many PRBs shall be blanked for BS to meet the coexistence and emissions requirement and assuming no new gNB channel filters. For UE, UE smallerCHBW SU >= 90 % sounds like just saying that a legacy channel bandwidth SU is >=90%.Then, it is always met and does not need to be stated at all (since all proposals can support at leat the legacy CBW). |
| 1. Study the complexity and efficiency of adding new channel bandwidths vs. using other including testing aspects.
 | -UE testing for irregularBW is needed. The CA framework can be reused.FFS if RB alignment between the two CCs should be required | -One carrier from BB perspective (single FFT is possible), and two carriers from RF perspective-[QC]: single FFT is not possible. The assume architecture for the Tx and Rx is based on NC CA which assumes separate FFTs. The proponents maybe can show a block diagram of how single FFT is possible(for either BS Tx or UE Rx)-[Apple]: we should have two FFTs and this solution will be become identical to overlapping CA. If we assume a single FFT for two separate RF front-ends, then it should be analysed further whether it is feasible and which UE design implications it will have.-RF capability of non-continuous intra-band CA is needed in DL, an optional UE capability Legacy UE will only access the network with one carrier-[Ericsson]: requires configuration of wider dedicated BWP compared to carrier BW-[Nokia]: RAN2 signalling already allows CBW of 1--275 PRBs: It's the UE capabilities that do not allow to signal anything else than what's specified in 38.101-X, as per the following excerpt from RRC: "Network only configures channel bandwidth that corresponds to the channel bandwidth values defined in TS 38.101-1 [15] and TS 38.101-2 [39]." Since this is worded as network restriction, it makes it clear that in case new values are added and network is aware of the UE capabilities, they can be signallled.-BS will maintain phase continuity between the two carriers | - Coordination at network side for SSB overlap between UE CHBW #1 and UE CHBW #2-[Nokia]: may require duplicated SSBs/other radio resources which may conflict in frequency domain -> SSB to be transmitted in a staggered manner in time domain (scheduler complexity)-[Huawei]: the complexity is the same as introduce number of the BS new channel bandwidth | -WiderCHBW alignment and its allocated BWP depending on the irregular CHBW position in the band needs to be determined(ref: R4-2107253)- new channel filter implementation?-how co-existence is ensured?-How to define the number of blanking RBs?How coexistence will be ensured?We can study the combination of the existing channel filter with the RF filter for a widerCBW shifted case which dwould not need new requirements |
| 1. Generic solution(s) should be intended as much as possible, with priority should be given to approaches that avoid the introduction of new channel BWs on the UE side. Proprietary solutions if proven relevant should not be precluded. Spectrally efficient methods providing a fine channel bandwidth granularity as well as low to moderate guard band width and signalling overhead should be preferred
 | - CHBW for SSBs (dependent on IrregularBW size) hence not generic-coordination /configuration of UE CHBW for SSBs (dependent on IrregularBW size)- [Huawei]: flexibility for the configuration on SSB, rather than not generic- [Huawei]: no new UE channel BWs is introduced- [Huawei]: in general two SSBs are configured per carrier. Single SSB is only configured for Pcell is not excluded, e.g. for the case new UE is the majority.  | -yes applies for all licensed spectrum wider than 5 MHz -[Huawei]: The dedicated BW should be from the set of channel bandwidths defined in 38.101. To this end, the transmission bandwidth configuration have to be defined for each combination from operators. Based on our understanding, similar effort is needed as the new UE channel bandwidth approach.-[Nokia]: The transmission BW configuration of each of the 2 overlapping RF carriers can remain the same as the specified transmission BW configuration for the respective RF carrier's bandwidth. -[Nokia]: solution applies not only to considered spectrum blocks within this SI as well as very limited impact to specification comparing to other methods- [Nokia]: low guard band width and signalling overhead since there is only one carrier from baseband perspective- [QC]: the guarband same as for overlapping CHBW or overlapping CA | -some additional implimentation efforts needed to TDM SSB for irregularBW < 10 MHz | -even it can apply for all licensed spectrum wider than 5 MHz, each scenario requires the set of relevant requirements |
| 1. Impact on RAN1 and RAN2 should be considered and minimized
 | -[Huawei]: no impact to RAN1 and RAN2 except UE capability to enable overlapping CA.-FFS if there is RAN2 impact | - UE capability signalling-[QC]: FFS if there is RAN1/2 impact (UE BWP needs to be fully contained in carrierbandwidth[Ericsson]: RAN1 change for BWP cannot be configured outside the grid configured in SIB1 in clause 12 of [5, TS 38.213-[Nokia]: Our assumption is that the carrier BW and grid are reconfigured in connected mode by utilizing the existing RAN2 flexibility so that no RAN1 change is needed. | -no change | -UE capability signalling-How to let UE know the RBs are blanking? |
| 1. For any considered solution, UEs not supporting such solution (both legacy and new UEs) should be able to use the next lower supported channel bandwidth in the UL and DL without implications.
 | - support legacy UE in both sides of irregularBW-new UE is optional suport the irregularBW via overlapping CA | --[Huawei]: Legacy UE can only operate in one side of the irregularBW.-[Nokia]: With a single SSB, this may be the case for some scenarios <10 MHz, but it should not apply to >10 MHz. | -legacy UEs | -legacy or new UEs |
| 1. Impact (if any) on RAN4 requirements should be identified for the preferred solutions.
 | -[Ericsson]: Define CA combinations in additions to NR BWs-Define CA combinations + - [Huawei]: define overlapping CA channel spacing. The existing CA requirements can be reused-FFS there is significant RAN4 impact | -very limited since requirements would be based on existing requirements for 5/10MHz CHBW | -BS irregularBW (Indicated carrierbandwidth will be one of the regular CBWs) | -BS irregularBW (Indicated carrierbandwidth will be one of the regular CBWs) BS will need to meet the OBUE requirements corresponding to the operator’s block-[Nokia] co-existence need to be addressed on both Tx and Rx side.-[QC]:set of new RF requirements for each scenario |
| 1. Benefits from system and UE point of view (comparisons among all candidate solutions)
* SSB/raster positions
* How many PRBs will be used based on one example
* Gain vs. BS and UE implementation complexities
 | Benefits to be shown in comparison with non-overlapping CA | -[Nokia]: One SSB, SU for both gNB and new UEs:6MHz – 30 PRBs (90%)7MHz – 36 PRBs (92.6%)11MHz – 58 PRBs (94.9%)12MHz – 63 PRBs (94.5%)13MHz – 69 PRBs (95.5%)* Future proof solution (not limited to considered spectrum blocks within this SI)
* No impact to RAN2 signaling as well as to RAN1 specifications
* No additional channel filters need to be designed and tested
* 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
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R4-2104886:

 Table 2-1: Exemplary number of RBs based on the next larger channel guard bands (15kHz SCS).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Channel (MHz) | Next larger channel (MHz) | Next larger channel guard band (kHz) | Next larger channel Nrb | Channel Nrb | Channel guard bands (kHz) | Utilisation (%) |
| 6 | 10 | 312,5 | 52 | 29 | 382,5 | 87 |
| 7 | 10 | 312,5 | 52 | 35 | 342,5 | 90 |
| 11 | 15 | 382,5 | 79 | 56 | 452,5 | 91,6 |
| 12 | 15 | 382,5 | 79 | 62 | 412,5 | 93 |
|  |  |  |  |  |  |  |
| 13 | 15 | 382,5 | 79 | 67 | 462,5 | 92,8 |

Table 2-2: Exemplary number of RBs based on the next larger channel guard bands (30kHz SCS).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Channel (MHz) | Next larger channel (MHz) | Next larger channel guard band (kHz) | Next larger channel Nrb | Channel Nrb | Channel guard bands (kHz) | Utilisation (%) |
| 6 | 10 | 665 | 24 | 12 | 825 | 72 |
| 7 | 10 | 665 | 24 | 15 | 785 | 77,1 |
| 11 | 15 | 645 | 38 | 26 | 805 | 85,1 |
| 12 | 15 | 645 | 38 | 29 | 765 | 87 |
|  |  |  |  |  |  |  |
| 13 | 15 | 645 | 38 | 32 | 725 | 88,6 |

R4-2107253:

**Table 2: options for irregular channel BW support based on meeting 100kHz raster.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Target BW** | **SCS** | **CH BW /****RB / SU%** | **IrrBW RB /** **SU %** | **SSB constraint** | **other** |
| **6 MHz** | **15 kHz only** | **5 / 25 / 75%** | **30 / 90%** | **15 kHz common in exact 20RB overlap****Need to be on SSB raster point** | **50kHz GB shift** |
| **7 MHz** | **15 kHz and****30 kHz** | **5 / 25 / 64%** | **35 / 90%** | **15kHz Partial overlap only, need to be staggered in time and SSB raster point** | **Lost BW due to SSB resources** |
| **11 MHz** | **15 kHz only** | **10 / 52 / 85%** | **57 / 93%** | **Common 15 kHz SSB** | **50kHz GB shift** |
| **12 MHz** | **15 kHz and****30 kHz** | **10 / 52 / 78%****10 / 24 / 72%** | **62 / 93%****29 / 87%** | **Common 15 kHz SSB** | **none** |
| **13 MHz** | **15 kHz and****30 kHz** | **10 / 52 / 72%****10 / 24 / 67%** | **62 / 86%****29 / 80%** | **Use 12 MHz solution** |
| **15 kHz only** | **10 / 52 / 72%** | **67 / 93%** | **Common 15 kHz SSB** | **50kHz GB shift** |