3GPP TSG-RAN WG2 Meeting #116 Electronic [R2-210xxxx](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-210xxxx.zip)

Elbonia, 01 – 12 November 2021

**Agenda item: 8.24.1**

**Source: Nokia (Rapporteur)**

**Title: Summary of [AT116-e][022][NR17] Irregular BW (Nokia)**

**WID/SID: FS\_NR\_eff\_BW\_util - Release 17**

**Document for: Discussion and Decision**

# 1 Introduction

This document is the report of the following email discussion:

Irregular BW

Offline first

* [AT116-e][022][NR17] Irregular BW (Nokia)

 Scope: Treat [R2-2109353](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2109353.zip), [R2-2109353](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2109353.zip), [R2-2109889](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2109889.zip), [R2-2109890](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2109890.zip), [R2-2111153](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2111153.zip), [R2-2110787](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2110787.zip), [R2-2109794](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2109794.zip), [R2-2109795](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2109795.zip), [R2-2110086](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2110086.zip), [R2-2110087](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2110087.zip)

 Determine agreeable parts, e.g. Reply LS. Identify discussion points for online (if needed).

 Intended outcome: Report (Reply LS in ph2)

 Deadline: Friday W1 (CB online)

[R2-2109353](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2109353.zip) LS on specification impact for methods on efficient utilization of licensed spectrum that is not aligned with existing NR channel bandwidths (R4-2114751; contact: Nokia) RAN4 LS in Rel-17 FS\_NR\_eff\_BW\_util To:RAN1, RAN2

[R2-2111209](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2111209.zip) Reply LS on specification impact for methods on efficient utilization of licensed spectrum that is not aligned with existing NR channel bandwidths (R1-2110584; contact: Nokia) RAN1 LS in Rel-17 FS\_NR\_eff\_BW\_util To:RAN4, RAN2

[R2-2109889](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2109889.zip) Discussion on irregular bandwidth ZTE Corporation, Sanechips discussion Rel-17 FS\_NR\_eff\_BW\_util

[R2-2109890](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2109890.zip) Reply LS on irregular bandwidth ZTE Corporation, Sanechips LS out Rel-17 FS\_NR\_eff\_BW\_util To:RAN4, RAN1

[R2-2111153](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2111153.zip) On efficient utilization of irregular spectrum Huawei, HiSilicon discussion Rel-17 FS\_NR\_eff\_BW\_util

[R2-2110787](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2110787.zip) Specification impact for methods on efficient utilization of licensed spectrum that is not aligned with existing NR channel bandwidths Ericsson discussion

[R2-2109794](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2109794.zip) Flexible bandwidth utilization Nokia, Nokia Shanghai Bell discussion Rel-17 FS\_NR\_eff\_BW\_util

[R2-2109795](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2109795.zip) Reply LS on flexibile bandwidth utilization Nokia, Nokia Shanghai Bell LS out Rel-17 FS\_NR\_eff\_BW\_util To:RAN4 Cc:RAN1

[R2-2110086](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2110086.zip) Discussion on irregular channel bandwidth LS from RAN4 Apple discussion Rel-17 FS\_NR\_eff\_BW\_util

[R2-2110087](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2110087.zip) [Draft] reply LS on irregular channel bandwidth feature Apple LS out Rel-17 FS\_NR\_eff\_BW\_util To:RAN4 Cc:RAN1

# 2 Contact Points

Respondents to the email discussion are kindly asked to fill in the following table.

|  |  |  |
| --- | --- | --- |
| Company | Name | Email Address |
| Nokia (Rapporteur) | Tero Henttonen | tero.henttonen@nokia.com |
| Apple | Naveen Palle | naveen.palle@apple.com |
| Qualcomm Incorporated | Masato Kitazoe | mkitazoe@qti.qualcomm.com |
| Huawei, HiSilicon | Yang Zhao | zhaoyang@huawei.com |
| MediaTek | Felix Tsai | chun-fan.tsai@mediatek.com |
| OPPO | Qianxi Lu | qianxi.lu@oppo.com |
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# 3 RAN4 questions to RAN1/RAN2

## 3.0 Background

RAN4 has been doing a study on how to support irregular bandwidths, for example 6, 7, 8, 11, 12, or 13 MHz that occur for certain operators. The work has been ongoing for a while, with RF aspects being discussed quite a bit but discussions taking a long time. To finalize the work, RAN4 sent the LS [R2-2109353](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2109353.zip) to both RAN1 and RAN2, and RAN1 already responded to it in [R2-2111209](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2111209.zip). The LS asks questions on each of the four main potential solution directions discussed in RAN4:

As per [TR38.844](https://www.3gpp.org/DynaReport/38844.htm), there are basically 4 different mechanisms considered in RAN4 (note that these are given in the order of the questions in the LS, which differs from the order in the TR):

1) Wider CBW (using of next larger channel bandwidth, e.g. 10 MHz CBW in case of 7 MHz spectrum, with scheduling restricted to the 7 MHz part only)

2) Overlapping CBW from network perspective (with UE being assigned two channel bandwidths that are partly overlapping to cover the desired area, e.g. using two 5 MHz blocks to cover 7 MHz spectrum)

3) Overlapping CBW from UE perspective, with two cells (i.e. using CA with overlapping spectrum to cover the desired area, e.g. PCell 5 MHz and SCell 5 MHz overlapping to create overall 7 MHz covered spectrum)

4) Overlapping CBW from UE perspective, with one cell (using next-smallest BWP/CBW in SIB1 and larger BWPs in CONNECTED, cell, e.g. using 5 MHz BWP/CBW in SIB1 and then 7 MHz CBW/BWP for new UEs in CONNECTED to cover 7 MHz spectrum)

Each of these has two questions associated with them, so the rest of the document considers the RAN2 aspects to answer those questions.

## 3.1 Wider CBW questions

The following RAN4 questions and RAN1 answers can be found in [R2-2111209](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2111209.zip) for this topic:

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| * For the wider CBW:
	+ clarify if there is any limitation for the UL carrier positions (not just BWP positions) legacy UEs support for *uplinkChannelBW-PerSCS-List* and *scs-SpecificCarrierList* in symmetric operating bands with a fixed duplex distance and asymmetric UL/DL channel bandwidth.
	+ RAN1 response: RAN1 specifications do not place any limitations to this for FDD bands as RAN1 specifications are agnostic to the definitions of operating bands, bandwidths and duplex distances while for TDD bands RAN1 requires that the active UL and DL BWP pair must have the same center frequency. It is RAN1 understanding that RAN2 capability and configuration signalling and RAN4 band, duplex and bandwidth definitions place restrictions to carrier positions.
	+ confirm UE behaviour if it is possible to configure a carrier that is not fully contained in the NR band, i.e. the carrier can extend beyond the low edge of the band and/or the high edge of the band?
	+ RAN1 response: RAN1 understanding is that there is no defined UE behaviour for a carrier that is not fully contained in a NR band as the UE capability of supported maximum bandwidth is defined on a per CC/per Band/Per BC basis, which assumes the indicated BW for a given CC is within a defined NR band.
 |

The RAN2 answers to these questions from companies seem mainly that there are few limitations apart from RRC assumptions. Some companies raise that the general assumption for the second question is that network should follow UE capabilities, but no other specific restrictions exist. The moderator also notes that RAN2 should focus on the RAN4 specification aspects when answering (e.g. justifying something on RAN4 specifications is perhaps not the most useful when answering to RAN4 - they should know their specifications already).

**Question 2**: What should be in RAN2 answers to the questions on wider CBW approach?

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| Answers to Question 1 |
| Company | Yes/No | Technical Arguments |
| Apple |  | Regarding carrier position:UL Carrier position is dependent on the NW configuration of pointA and offsetToCarrier, and so the starting position of the carrier is dependent on these two NW configurations. RAN2 specifications do not place any limitations on how the NW configures pointA and offsetToCarrier noting that in general, any configuration the NW provides is assumed to based on the UE capability to support this.Regarding outside of NR bandit is RAN2 understanding as well that the UE behavior is not defined if the carrier is not fully contained with an NR band, as the UE capabilities are defined assuming the UE operates within the NR bands as defined in 38.101 and the capabilities as defined in 38.331/38.306 |
| Qualcomm Incorporated |  | Our view is aligned in general with RAN1 response. RRC signalling allows flexible placement of channel BW, but the network should take into account the UE capability of the frequency band, which includes supported duplex distance and frequency range. |
| Huawei, HiSilicon |  | Regarding the question of **1)-a**, there is no explicit carrier positions limitation in RAN2 spec on configuration of *uplinkChannelBW-PerSCS-List* and *scs-SpecificCarrierList* in symmetric operating bands with a fixed duplex distance and asymmetric UL/DL channel bandwidth. Regarding the question of **1)-b**, since RAN2 spec is band agnostic and there is no specific handling for such case. Thus the UE behaviour is not determined if the carrier contains resources outside an NR band. In general if the UE is configured channel bandwidth that is larger than the network bandwidth, there may be unwanted interference falling into the UE’s receiver but this seems more RAN4 aspects. |
| MediaTek |  | On configuration limitationThere is no specific limitation (from signaling point of view) on carrier position or duplex distance. The configuration should of course be sensible (based on R1/R4 specification) and respect to UE capability.On configure a CBW that is outside a NR bandSimilar view as RAN1 response. The UE behavior is not specified in this case. |
| OPPO |  | In general, similar to RAN1 response.On configuring a CBW that is outside a NR band, it is not specified/defined yet. |
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**Summary 1**: TBD.

**Proposal 1**: TBD.

## 3.2 Overlapping CBWs from network perspective (one cell)

The following RAN4 questions and RAN1 answers can be found in [R2-2111209](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2111209.zip) for this topic:

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| * For the overlapping CBWs from network perspective (one cell approach):
	+ clarify whether a single SSB and CORESET (e.g. for cases where irregular BWs >10 MHz where a 4.28 MHz wide initial BWP can be in the common frequency range), can be used to configure UEs with different channel BWs on different parts of the BS channel.
	+ **RAN1 response**: In idle mode and inactive state, all UEs “camp” on the same initial BWP. Once connected, each UE can be configured to different parts of the carrier using a dedicated BWP. A single SSB is enough if a SSB position can be found that allows two UEs placed at either end of the frequency allocation and still receive the SSB within their respective dedicated BWPs, obviously as long as the configuration on each cell in this “one cell” approach is configured in compliance with the RAN1/2/4 specifications.
	+ clarify whether two time staggered SSBs and CORESET#0 on the same frequency (when the frequency separation is not enough to send them simultaneously at the same time and thus time staggering is needed) are supported in RAN1/2 specifications so that UEs configured with left and right channels of the next smaller regular size can track their own time staggered SSB and CORESET#0.
	+ **RAN1 response:** RAN1 specifications allow for configuring staggered SSBs and CORESET#0s on the same frequency so that UEs configured with left and right channels of the next smaller regular size can track their own time staggered SSB and CORESET#0.
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These questions are more about RAN1 details, and there are decent answers already, but RAN2 could offer some complementary answers on e.g. BWP handling for IDLE/INACTIVE, CD-SSB role and other SSB configuration aspects.

**Question 2**: What should be in RAN2 answers to the questions on overlapping CBW from network perspective (one cell) approach?

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| Answers to Question 2 |
| Company | Yes/No | Technical Arguments |
| Apple |  | Regarding singleSSB/CORESET:RAN2 specification allows the NW to configure the UE with a CH/BWP configuration using SIB1. A single SSB/CORESET can provide the UE with a SIB1, and while SIB1 can configure different channel BWs that are applicable to all UEs that camp on that cell, SIB1 cannot configure different channel BWs to separate UEs. So using a single SSB and CORESET it is NOT possible for the NW to configure different CH BWs to different UEs.Regarding staggered:RAN2 specification does not prevent the NW from staggered SSB/CORESET configurations, and while the NW might not be aware on which SSB/cell the UE selects first during cell selection, the NW can direct the UE to the intended SSB/cell in the later stages of cell selection and in cell reselection. |
| Qualcomm Incorporated |  | First question:Our view is in line with RAN1 response.Second question:We observed there are two interpretations for this questions in submitted documents, in particular on the “SSBs and CORESET#0 on the same frequency”.Our understanding of this scenario is that "absoluteFrequencySSB" is still different for those time-staggered SSBs, but frequency range of the SSBs and CORESET#0s is overlapping. In this case, those SSBs are simply represents two cells placed in different frequency positions.Another interpretation we saw is that "absoluteFrequencySSB" is exactly the same for those time-staggered SSBs. Still in this case, our understanding is that those SSBs will have to be associated with independent COREST#0, SIB1 and system information. Feasibility of such operation is questionable, or at least requires much amount of analysis. |
| Huawei, HiSilicon |  | Regarding question **2)-a**, it would be possible from network perspective to use a single SSB and CORESET to configure the UE with different channel BWs on different parts of the BS channel. However, it also implies that the configuration in SIB1 needs to be re-configured with dedicated signaling in order for UE to use each different part respectively. It should be noted that in last RAN2 meeting, it was agreed that the UE can be configured with dedicated cell/BWP bandwidth that is not within channel bandwidth in SIB1 as below:* [016] R2 Confirms the following understanding:

When configuring a UE with a dedicated BWP that is not within the channel bandwidth that the UE applied when acquiring SIB1, the network configures the downlinkChannelBW-PerSCS-List and/or uplinkChannelBW-PerSCS-List and firstActiveBWPID so that the channel bandwidth covers at least the active BWP. UE behaviour is not specified when channel bandwidth doesn't contain active BWP size.The network avoids DCI- and timer-based BWP switching to BWPs that are not within current channel bandwidthIn this regard, we think the option is possible from the RAN2 point of view. We understand this option does not require SIB to configure the different channel bandwidths, instead it uses dedicated signalling to configure different channel bandwidths for different UEs in connected mode. Regarding question 2)-b, if the overlapped bandwidth is smaller than the bandwidth of SSB/CORESET0, then two SSB/CORESET0s might be needed. However, in such case, if TDM manner is used, the location of the carrier indicated for these two SSB would be different, and thus these two SSBs would be seen as two different cells and this might not belongs to one cell approach, if they are regarded as the same cell the UEs have no idea which location is used as the reference. In such cases the cost for additional SSB/CORESET0 (SIB/Paging) would be considerable given that the total bandwidth is not large, and the corresponding utilization of such irregular spectrum seems not efficient via this solution. In general we think we should first clarify different scenarios on these irregular channel bandwidth and then provide answers. |
| MediaTek |  | On Single SSBTwo UE could of course camp on a cell based on single SSB (assuming that it is Cell defined SSB). However, there is only one initial BWP configured in this CD-SSB. So, the two UE cannot be configured with different initial CBW. The CBW could be changed after go into connect mode.On staggered SSBThere is no clear limitation on this kind of SSB deployment in R2 specification. The UE will consider this two SSB as from two different cell. And it is unclear that which SSB the UE will find while trying to camp on a cell in this frequency.  |
| OPPO |  | On single SSB:Similar view as RAN1, and as debriefed by MTK, single SSB means single initial BWP, while different CBW happens only after entering into CONNCTED state.On staggered SSB:Similar to the observation by QC, it would be good to firstly clarify the scenario a bit more, i.e., the “two-cell” approach ("absoluteFrequencySSB" is different) vs. the “mixed-one-cell” ("absoluteFrequencySSB" is same). After that, further analysis can be provided (especially on the latter one). |
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**Summary 2**: TBD.

**Proposal 2**: TBD.

## 3.3 Overlapping CBWs from network perspective (two cells/CA)

The following RAN4 questions and RAN1 answers can be found in [R2-2111209](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2111209.zip) for this topic:

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| * For the overlapping CBWs from UE perspective (two cell approach / CA approach):
	+ if two different Bandwidth Parts for the UE are overlapping, and both contain a subset of CSI-RS resources that are mapped to the same subset of overlapping RBs for the same UE, please clarify how does UE report CSI for the overlapped part, e.g. does UE report CSI for each cell separately, or just once for the overlapping part, or something else?
	+ clarify how PDCCH reception in overlapped CA when PCell and SCell PDCCH resources partially overlap and whether there are any impacts to cross-carrier scheduling
* RAN1 response:
	+ RAN1 specification do not restrict configuring overlapping carriers for CA for a single UE. However, RAN1 would like to note that in Rel-15/16 RAN1 did not discuss UE capabilities for overlapped CA in Rel-15/16, and it is RAN1 understanding that RAN2-specified UE capability signalling does not provide any possibility for UE to indicate support for overlapped CA.
	+ In case of CA, the CSI-RS measurement and reporting for the component carriers are specified in TS38.213 to be performed independently per-carrier and PDCCH monitoring are also specified in TS38.213 to be performed independently for each component carrier.
	+ gNB scheduler is responsible for avoiding collisions of different transmissions as a network restriction for the overlapping part with overlapped CA including cross-carrier scheduling as well.
	+ RAN1 would like to note that overlapped CA configuration case has not been considered in RAN1 and the UE capabilities agreed in RAN1 for Rel-15/16 were not designed to be able to indicate UE’s support for overlapped CA configuration.
 |

These questions seem almost solely about RAN1 aspects, but RAN2 could note that from configuration viewpoint, two cells have independent configurations. But overall most companies already think these questions are mainly for RAN1 to answer, and they have already done that. What RAN2 can add is mainly the configuration and UE capability details.

**Question 3**: What should be in RAN2 answers to the questions on overlapping CBW from network perspective (two cells/CA) approach?

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| Answers to Question 3 |
| Company | Yes/No | Technical Arguments |
| Apple |  | Regarding overlapping from UE perspective from CA approach,we think RAN2 does not need to answer.  |
| Qualcomm Incorporated |  | Our view is in line with RAN1 response. In general these case have not been assumed by RAN2 in the current CA design. We suggest RAN2 confirm RAN1’s understanding on UE capability for overlapping CA (the first bullet of their response). |
| Huawei, HiSilicon |  | Regarding 3aIt is allowed from RAN2 signaling point of view to configure the UE to use one of the configured resource for CSI report or CORESETs for PDCCH reception at a time, or possible not to configure them overlapped. However, it should first be clarified whether legacy UEs can support such configuration, and discuss whether contiguous or non-contiguous CA BC capability can be applied for this scenario.Regarding 3b, we think RAN1 should answer this. |
| MediaTek |  | We understand that the legacy UE does not support this and new capability is needed for overlapping CA.  |
| OPPO |  | We understand that the legacy UE does not support this and new capability is needed for overlapping CA.  |
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**Summary 3**: TBD.

**Proposal 3**: TBD.

## 3.4 Overlapping CBWs from UE perspective (one cell)

The following RAN4 questions and RAN1 answers can be found in [R2-2111209](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2111209.zip) for this topic:

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| * For the overlapping CBWs from UE perspective (one cell approach):
	+ Is it possible to configure the UE with a dedicated *carrierBandwidth* in the *ServingCellConfig* that is wider than/partially outside the *carrierBandwidth* configured in SIB1?
	+ RAN1 response: RAN1 leaves the configuration related question for RAN2 to answer.
	+ Clarify for equalization purposes in the DL, does the BS need to know the split between the subset of PRBs from a main RF carrier versus PRBs from an additional RF carrier are received on different channel/antenna before combining. If pre-coding assumes all PRBs experience the same channel/antenna, is signalling required so that BS pre-coding can account for the path differences of main carrier PRBs and additional carrier PRBs.
	+ RAN1 response: RAN1 has not evaluated, nor plans to evaluate the need for the gNB to know this aspect.
 |

The first question is asking about RAN2 specification restrictions and can be answered by RAN2, but the second question clearly seems to be about RAN1 (and RAN4!) aspects. There are some different views among the companies on the first question, so it would be good to highlight the background to their proposed answer in more details.

**Question 4**: What should be in RAN2 answers to the questions on overlapping CBW from UE perspective (one cell) approach?

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| Answers to Question 4 |
| Company | Yes/No | Technical Arguments |
| Apple |  | From ASN.1 signaling perspective, it should be possible for the NW to configure a UE dedicated carrier bandwidth that is different from the SIB1 configured BW, as long as the configuration aligns with the UE capability. |
| Qualcomm Incorporated |  | The current RRC signalling allows overriding SIB1 channel BW by dedicated channel BW. |
| Huawei, HiSilicon |  | Similarly as Q2, we understand it is possible from RAN2 signaling to configure the UE with a dedicated carrierBandwidth in the ServingCellConfig that is wider than/partially outside the carrierBandwidth configured in SIB1.We understand the difference compared with Q2 is that for new UEs supporting irregular bandwidth, this solution can also configure irregular channel bandwidth to the UEs; while for legacy UEs, only regular channel bandwidth is configured to them.  |
| MediaTek |  | It is possible to configure dedicate CBW (different from initial BWP from SIB1) according to UE capability. |
| OPPO |  | It is possible to configure dedicate CBW (different from initial BWP from SIB1) according to UE capability.And share HW observation that “the difference compared with Q2 is that for new UEs supporting irregular bandwidth, this solution can also configure irregular channel bandwidth to the UEs; while for legacy UEs, only regular channel bandwidth is configured to them”. |
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**Summary 4**: TBD.

**Proposal 4**: TBD.

# 4 Conclusion

TBD.