**3GPP TSG-RAN WG2 Meeting #116bis-e R2-2201747**

**Online, January 17~25 2022**

**Agenda item: 8.19 Coverage enhancements**

**Source: Qualcomm Incorporated**

**Title: Report of [AT116bis-e][111][CovEnh] General aspects**

**Document for: Discussion and decision**

1. Introduction

This document is to report the outcome of the following offline discussion at RAN2#116bis-e Meeting:

* [AT116bis-e][111][CovEnh] Coverage enhancements (Qualcomm)

Initial scope: Continue the discussion on the remaining proposals in the submitted contributions

Initial intended outcome: Summary of the offline discussion with e.g.:

  List of proposals for agreement (if any)

  List of proposals that require online discussions

  List of proposals that should not be pursued (if any)

Initial deadline (for companies' feedback): Thursday 2022-01-20 2200 UTC

Initial deadline (for rapporteur's summary in R2-2201747): Friday 2022-01-21 0200 UTC

**Note:**

*Proposals in [2] and [10] do not appear to be related to coverage enhancements and hence are not included in this discussion.*

2. Contact Information

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| Company | Contact: Name (E-mail) |
| Huawei, HiSilicon | louchong@huawei.com |
| Ericsson | Jonas.sedin@ericsson.com  |
| Nokia, Nokia Shanghai Bell | samuli.turtinen@nokia.com  |
| Qualcomm | Linhai He (linhaihe@qti.qualcomm.com) |
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3. Discussion

## 3.1 Msg3 repetition for CFRA

In [12] it is proposed that Msg3 (PUSCH scheduled by RAR UL grant) repetition is also supported for CFRA, based on a working assumption made by RAN1:

**Working assumption**

* support repetition for a PUSCH scheduled by RAR UL grant, including both Msg3 PUSCH and CFRA PUSCH.
	+ Use the same mechanism of Msg3 PUSCH repetition, when applicable, for CFRA PUSCH with repetitions.
	+ No separate CFRA preamble/RO for repetition of CFRA PUSCH is introduced.
	+ No additional optimization specific for CFRA PUSCH is considered for CFRA PUSCH with repetition.
	+ No additional RAN1 specification impact

On the other hand, in [13] it is argued that from RAN2’s perspective Msg3 repetition is not applicable to CFRA.

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| R2-2201598 | On Type A PUSCH repetitions for Msg3 | Ericsson | Proposal 3 CFRA for Msg3 (PUSCH scheduled by RAR) is only applicable to reconfiguration with sync.Proposal 4 CFRA for Msg3 (PUSCH scheduled by RAR) can be enabled by the network signalling how the UE shall interpret RAR in the CFRA/RACH-ConfigDedicated configuration.Proposal 5 Introduce a flag in CFRA configuration on how RAR shall be interpreted for CFRA.Proposal 6 Take the RRC excerpt as a baseline for introducing Msg3 repetitions for CFRA. |
| R2-2201617 | Remaining issues on RAN2 support of Msg3 PUSCH repetition | Huawei, HiSilicon | Proposal 1: From RAN2 perspective, Msg3 repetition is not applicable to 4-step CFRA. |

**Q1**: From RAN2’s perspective, do you think Msg3 repetition for CFRA should be supported? Please note that only those cases of CFRA with RAR are considered for this question (For example, CFRA BFR is excluded).

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| Company | Yes/No | Comments |
| Huawei, HiSilicon | No | From our understandings, it doesn’t make much sense to support CFRA for “Msg3 repetition“ since CFRA can be only triggered when RSRP is above a threshold, which is contradictory with the condition of requesting Msg3 repetition. In addition, we are concerned it will also involve more standard efforts, e.g. to align the UE and NW understanding on how to interpret RAR (as in Q2). So it can be seen as optimization and thus should not be pursued for now.  |
| Ericsson | Yes | From our understanding, the same reason for introducing msg3 repetitions and increased amount of repetitions for PUSCH that is being introduced is valid for CFRA scheduled by PUSCH, i.e to increase reliability and we do not think it is only true that CFRA is perfomed only in good conditions. Msg3/PUSCH scheduled by RAR is still the weakest link of the random access procedure, regardless of CBRA or CFRA. RAN1 has a working assumption, where in the latest feature summary seems to indicate that it will be made into an agreement and the latest RAN1 feature list, “PUSCH scheduled by RAR“ is mentioned rather than msg3 repetitions. Regarding implementation challenges, we have a proposal below that can achieve what RAN1 has been discussing, but RAN1 has also been discussing other alternatives. Aligning network and UE understanding is not difficult as in CFRA it is the network the decides on the understanding of RAR and does not require a lot of standard changes, nor procedural changes as the difference is the does not have to select by itself.  |
| Nokia | No | CFRA usage is subject to the beam being above a threshold level which the NW can control. |
| Qualcomm | See comment | Technically, we assume the selection between CFRA, CFRA with repetition, CBRA and CBRA with repetition would be based on RSRP thresholds. If RSRP threshold for CFRA with repetition is configured between those for CFRA and CBRA, then CFRA with repetition can cover the case where UE’s RSRP is not strong enough to use legacy CFRA but can take advantage of CFRA with the help of Msg3 repetition. However, selection based on RRC configuration, as proposed in [12], seems quite inefficient. For example, P4 & 5 in [12] require that if network includes a repetition indication in dedicated RACH configuration, then Msg3 always uses repetition, regardless of UE’s link quality. |
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If Msg3 repetition for CFRA is supported, then UE needs to know if it is enabled in order to properly decode the UL grant provided in RAR. Since RAN1 did not discuss this issue, it would have to be implemented by upper-layer methods.

**Q2:** If Msg3 repetition for CFRA is supported, in your view how Msg3 repetition for CFRA may be enabled?

* Option 1. By RRC configuration, as in Proposal 4 and 5 in [12];
* Option 2. Other methods.

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| Company | Option 1/2 | Comments |
| Huawei, HiSilicon | None or Option 2 | See comments to Q1. We also notice RAN1 is discussing the similar issue, so we should avoid redudant discussion (if Msg3 rep for CFRA is supported) |
| Ericsson | 1 | We think that proposal 1 is a clean method, but we should discuss and evaluate other methods. |
| Nokia | None (if agreed, then Option 1) |  |
| Qualcomm | Option 2 | Network can configure a RSRP threshold for CFRA Msg3 repetition and two dedicated preambles for a UE. One of the preamble is for UE to indicate its RSRP requires Msg3 repetition, and the other is for legacy CFRA |
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## 3.2 Order between RA-type selection and CE selection

In [5] and [8] it is discussed that whether UE should select CE before selecting RA type, as captured in the proposals listed below. Please note that this issue is discussed in the common RACH session as well. In this offline discussion, please comment from only CE’s perspective, i.e. no other RACH features are involved.

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| R2-2200272 | Remaining issues related to coverage enhancement | Xiaomi | Proposal 1 CE selection is performed after RA type selection and when 4-step RA type is selected.  |
| R2-2201177 | Further Discussion on RAN2 Impacts of Msg3 Repetition | vivo | Proposal 1: From CovEnh perspective, Msg3 repetition request validation is performed ahead of RA type selection. |

**Q3**: From purely CE’s perspective, which of the following order between RA type and CE do you think UE should follow when initiating a RACH procedure?

* Option 1: CE selection is performed **after** RA type selection;
* Option 2: CE selection is performed **before** RA type selection;
* Option 3: other views (Please clarify in your comment).

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| Company | Option 1/2/3 | Comments |
| Huawei, HiSilicon | Option 2 | Both works and will have the same results, and we prefer to have a unified framework, so Option 2 seems more aligned with common RACH agreements.  |
| Ericsson |  | To my understanding we already brought this up online and no one had any objections: Note: Agreements from RACH indication and partitioning session: 1. CE will also be considered as part of the feature combination for each RACH partition. The eligibility criteria for CE will be determined before the RACH partition selection is performed. [CB need to confirm that it is compatible with the CE agreements]

I assume it is up to RACH Indication and Partitioning (RIP) to implement this now in a manner that makes their procedures consistent.  |
| Nokia | Option 2 | It seems unlikely the UE would anyway end up to 2-step RACH if CE required. |
| Qualcomm | Option 3 | We should leave this to common RACH discussion. It does not make sense to look at this issue in isolation. |
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## 3.3 CE-specific carrier selection threshold

In [3] and [13], it is proposed that a new RSRP threshold should be introduced for CE-capable UEs in its selection of UL carrier for RACH.

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| R2-2200251 | Discussion on CE’s impact on UL carrier selection | OPPO | Proposal 2 Introduce a CE-specific rsrp-ThresholdSSB-SUL parameter for CE-capable UEs to select SUL/NUL carrier.Proposal 3 The CE-specific rsrp-ThresholdSSB-SUL parameter has a lower value than the existing rsrp-ThresholdSSB-SUL parameter. |
| R2-2201617 | Remaining issues on RAN2 support of Msg3 PUSCH repetition | Huawei, HiSilicon | Proposal 6: A new RSRP threshold is needed for the Msg3 repetition capable UE to perform carrier selection when NUL supports Msg3 repetition.Proposal 7: The new RSRP threshold for the Msg3 repetition capable UE to perform carrier selection is configured per BWP, but the value applies to all the BWPs. |

**Q4**: Do you think a new RSRP threshold should be introduced for CE-capable UEs in its selection of UL carrier for RACH? If you do, please indicate in your comment what granularity this new RSRP threshold should be configured at (e.g. per BWP as proposed in [13] or something else).

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| Company | Yes/No | Comments  |
| Huawei, HiSilicon | Yes  | Proponent. Without having a new RSRP threshold, the UE will only be able to select SUL even if NUL with CE can provide better coverage, which is not desirable. So it is reasonable to introduce a new RSRP threshold to better distribute the UEs considering NUL is configured with CE. Regarding the configuration in RRC, we don’t see much difference from the legacy carrier selection threshold, i.e. configured per BWP, but the value applies to all the BWPs of this UL carrier. |
| Ericsson | No | We can see the problem, and similar problems exist for instance for 2-step random access, where there could be a scenario where 2-step is configured for SUL, but may not be selected. Similar cases exist for other random access configurations where the coverage is affected. In the end nothing was done about this. The problem is that with coverage enhancement being a part of feature indication group as per RIP WI it becomes a lot more complicated. Our understanding is that current procedures in RIP is that UE first performs carrier selection, then BWP selection and then the selections related to RACH partition is selected. If we now introduce a specific carrier selection threhold for CE UEs, the UE has still not evaluated whether CE is possible to select given that the RACH partitions may contain other features that the UE may not support. Thus for this to work, UE somehow have to select/evaluate RACH partition before UL carrier selection, which has separate problems. The consequence of not introducing this is probably not that severe as SUL is already a feature introduced to increase coverage. I think since we already have so many thresholds introduced, it is very challenging to support every single case and this is something RAN2 has to live with. Note that CE is still possible both for SUL and NUL and we are in no conflict with any agreements.  |
| Nokia | No | Configuration issue. |
| Qualcomm | No | We do not think CE-capable UE needs a separate threshold for UL carrier selection. Repetition gives the same improvement in link budget on both NUL and SUL.  |
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## 3.4 BWP with only CE RACH configuration

In [7] and [13] it is discussed whether a dedicated UL BWP can be configured with only CE RACH resources.

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| R2-2200603 | Remaining issues on Msg3 repetition in CE | ZTE, Sanechips | Proposal 3: RAN2 to select one of following options for CE RACH configuration:• Option 1: Dedicated BWP with only CE RACH resources is not supported. When configures RACH resources in dedicated BWP, it must include RACH resources for non-CE. • Option 2: Dedicated BWP with only CE RACH resources is supported, in this case, Msg3 repetition RSRP threshold is not configured, and UE should always trigger CE RACH when this BWP is activated.  |
| R2-2201617 | Remaining issues on RAN2 support of Msg3 PUSCH repetition | Huawei, HiSilicon | Proposal 3: RAN2 confirms that it is feasible to configure either CE RACH resources only or non-CE RACH resources only on the selected UL BWP.Proposal 4: In case only the CE RACH resource is configured on the selected UL BWP, the UE shall perform CE RA without evaluating RSRP.Proposal 8: The RSRP threshold for requesting Msg3 repetition should be configured per BWP, and is only present if both CE RACH resources and non-CE RACH resources are configured for the BWP. |

**Q5:** Do you think a dedicated UL BWP can be configured with only CE RACH resources?

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| Company | Yes/No | Comments |
| Huawei, HiSilicon | Yes | We don’t see a need to restrict NW flexibility, similar to 2-step RA configured only case. |
| Ericsson | Yes | Agree with Huawei |
| Nokia | Yes |  |
| Qualcomm | No | This proposal is against the current RAN1 agreement, which requires CE RACH to share preambles and/or ROs with other RACH configurations. CE RACH cannot have its own dedicated RACH resources. |
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## 3.5 Beam specific CE RACH

In [6] it is proposed that Msg3 repetition can be configured on a per-SSB basis for better utilization of RACH resources, when different SSBs have different channel conditions. Otherwise, it may result in uneven cell coverage or inefficient use of RACH resources.

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| R2-2200421 | Consideration on RAN2 impacts of Msg3 repetition | CATT | Proposal 3: In order to reduce the impact on legacy UEs, Msg3 repetition can occur on some specified RACH resource, e.g. partials SSBs.Proposal 4: By introducing an indication parameter, e.g. bitmap, to indicate which SSB can be used for Msg3 repetition. |

**Q6:** Do you think Msg3 repetition can be configured on a per-SSB basis? If you do, please indicate in your comment how it may be signalled.

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| Company | Yes/No | Comments |
| Huawei, HiSilicon | No | We don’t think it is essential and no much benefit can be seen.  |
| Ericsson | No | Similar things were suggested for 2-step. In theory there can be benefits, but it is a big optimization that changes fundamental RACH configurations such as SSB to RO mapping etc and would probably have big impact on RIP implementation. |
| Nokia | No |  |
| Qualcomm | No | We have sympthy for the motivation behind the proposal but are afraid that it would have considerable impact on the RACH configuration, which is already quite compliciated with multiple RACH partitions |
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## 3.6 Prioritized RACH and CE

In [12] it is proposed that if a UE is eligible to use prioritized RACH, it is allowed to use CE-specific RACH resources, even if the UE does not meet the RSRP requirement for CE RACH. The motivation is that using CE-specific RACH resources can help prioritized RACH be more robust and faster.

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| R2-2201598 | On Type A PUSCH repetitions for Msg3 | Ericsson | Proposal 2 If the UE is prioritized, the UE can be configured to select msg3 PRACH resources. |

**Q7:** Do you think prioritized RACH should be allowed to use CE-specific RACH resources even if the UE does not meet the RSRP requirement for CE RACH?

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| Company | Yes/No | Comments |
| Huawei, HiSilicon | No | Not aligned with previous agreements, and this proposal will affect other CE UE RACH performance. So we are not okay with this proposal. |
| Ericsson | Yes | We are the proponent and we think it can be beneficial for many use cases such as public safety, which was introduced in rel-16 for 4-step and 2-step random access.  |
| Nokia | No |  |
| Qualcomm | No | In our view prioritization and repetition are two independent enhancements. Prioritization is applied based on type of RACH triggers and repetition is applied based RSRP. In the current framework, a prioritized RACH already can benefit from msg3 repetition when UE has poor RSRP. There is inefficient and unnecessary to always apply repetition even if a prioritized RACH has good RSRP. |
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## 3.7 RAN1 related proposals

In [1] it is proposed that UE should re-/start DRX RTT or reTx timer at boundaries of time domain windows to better support joint channel estimation. The motivation is that during a joint domain window UE does not perform DL monitoring on PDCCH or DL reception on PDSCH (except certain DL slots). Therefore, DRX RTT timer or reTx timer should not be running within a time domain window, even after UE has performed the initial Tx of a repetition.

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| R2-2200192 | Issues on coverage enhancements | Qualcomm | Observation 1. Joint channel estimation (JCE) for PUSCH Tx, together with time domain window (TDW), is configured by RRC. Observation 2. Network may configure multiple TDWs for a PUSCH repetition.Observation 3. Within a TDW, UE needs to maintain consistent Tx power level and phase continuity within TDWs of a PUSCH transmissions enabled with JCE. Proposal 6. When UE in a TDD system is configured with JCE and TDW(s), UE applies the following behaviors for DRX RTT timer and DRX reTx timer:- UE starts DRX RTT timer only when a time domain window ends;- UE starts DRX reTx timer upon expiry of DRX RTT timer, only if no TDW is active;- UE stops DRX RTT timer or DRX reTx time, if running, when a TDW starts. |

**Q8.** Do you think enhancements to DRX RTT timer and reTx timer are necessary when time domain window is configured? If you do, please indicate in your comment whether you support the enhancements proposed in [1] (see above).

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| Company | Yes/No | Comments |
| Huawei, HiSilicon | No | It seems not essential to optimize DRX for JCE and not in the WID scope. If the UE power is a concern, it can be up to NW to configure a proper RTT timer to cover the TDW.  |
| Ericsson | Not sure | We are fine to discuss it further, but we tend to believe that DRX timers should have priority over JCE window, otherwise scheduling will be challenging. Also, it seems that the JCE window is very short (2, 4, 8 slots) and the DRX timers should be able to take this in to account. |
| Nokia | No |  |
| Qualcomm | Yes | Proponent. We expect typical TDWs have longer duration than DRX RTT timer. So we are concerned that RTT timer and reTx timer may expire before end of TDW, causing HARQ failure. We are not sure if the problem can be completely avoided by network configuration.  |
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In [13], it has been proposed that msg3 repetition can be modelled in the same way as dynamically scheduled bundles. A TP is provided the Appendix in [13] for reference.

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| R2-2201617 | Remaining issues on RAN2 support of Msg3 PUSCH repetition | Huawei, HiSilicon | Proposal 10: The bundling operation is applicable to Msg3 repetition, and the repetition number is determined from lower layer, similar to bundling of dynamic grant and configured grant. |

**Q9.** Do you think Msg3 repetition should be modelled in the same way as dynamically scheduled bundles, as proposed in [13]?

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| Company | Yes/No | Comments |
| Huawei, HiSilicon | Yes  | Proponent. For Msg3 rep initial tx, the repetition number is indicated in the MCS field carried in RAR, and for Msg3 rep retx, the repetition number is indicated in PDCCH, which are both transparent to MAC. So we think the bundling operation should be aligned with DG and CG. The TP can be merged into MAC running CR for detailed review. |
| Ericsson | Yes | The TP seems reasonable |
| Nokia | Yes |  |
| Qualcomm | Yes |  |
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## 3.8 Configuration granularity of RSRP thresholds

In [13] it was proposed that RSRP threshold for requesting Msg3 repetition should be configured per BWP, and is only present if both CE RACH resources and non-CE RACH resources are configured for the BWP.

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| R2-2201617 | Remaining issues on RAN2 support of Msg3 PUSCH repetition | Huawei, HiSilicon | Proposal 8: The RSRP threshold for requesting Msg3 repetition should be configured per BWP, and is only present if both CE RACH resources and non-CE RACH resources are configured for the BWP. |

**Q10.** Do you agree with Proposal 8 in [13]?

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| Company | Yes/No | Comments |
| Huawei, HiSilicon | Yes | Proponent. Note that the RSRP threshold for requesting Msg3 repetition per carrier has been confirmed in RAN1 and RAN2.Agreements:1. Confirm Msg3 repetition is supported on both NUL and SUL, and network can configure different RSRP thresholds for requesting Msg3 repetition on NUL and SUL.

Regarding the configuration of the thresholds, we don't see much difference from the RSRP threshold for 2-step RA, i.e. configured per BWP and only present if both CE RA and non-CE RA resources are configured for the BWP. We understand this threshold is also relevant to the leftover from common RACH session as follows.1. CE will also be considered as part of the feature combination for each RACH partition. The eligibility criteria for CE will be determined before the RACH partition selection is performed.  [CB need to confirm that it is compatible with the CE agreements]

We understand whether this WA is compatible with above CE agreements depends on whether it requires a UE-specific CE threshold, rather than carrier-specific CE threshold. If it should be UE-specific CE threshold, then we don’t see how it can be compatible since different thresholds will result in different results and also impact the gNB implementation on SUL and CE features (see the following figure, where UE specific CE threshold and carrier specific threshold are used in the upper and lower respectively). Given no technical reason is received on carrier-specific threshold, we think it is too late to revert CE agreements, which was from RAN1 who has better view of performances between SUL and Msg3 rep. So we are not okay to revert CE agreements and we think there can be solutions to have a unified RACH partition framework that can be further discussed in common RACH session.  |
| Ericsson | Not sure | We agree with the intention as similar was pursued for 2-step RA. But taking RIP into consideration I assume that the rsrp threshold would be used to determine whether the UE shall select the preamble partition related to msg3 repetitions. Whether it is present or not if there are CE and non-CE resources might not be as simple as for 2-step RA. Should be further discussed with RIP configuration in mind. |
| Nokia | Yes |  |
| Qualcomm | See comment | The threshold for requesting Msg3 repetition should be configured under RACH partition, not BWP configuration. In general, such configuration issues should be discussed in the common RACH session, which has a sub-agenda for signaling issues.  |
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In [13] it was proposed that the SSB selection threshold, *rsrp-ThresholdSSB*, should be configured per BWP and is only configured for the BWP with CE RACH resources.

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| R2-2201617 | Remaining issues on RAN2 support of Msg3 PUSCH repetition | Huawei, HiSilicon | Proposal 9: The separate SSB selection threshold for the UE who decides to requesting Msg3 repetition should be configured per BWP and is only configured for the BWP with CE RACH resources. |

**Q11.** Do you agree with Proposal 9 in [13]?

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| Company | Yes/No | Comments |
| Huawei, HiSilicon | Yes | Proponent. We think it is straightward to configure this SSB threshold per BWP as same as the current SSB threshold for non-CE CBRA SSB selection.  |
| Ericsson | Not sure | The comment to this is similar to Q10, but we are not sure whether this would be configured per RACH partition. Should be further discussed with RIP configuration in mind. |
| Nokia | Maybe | It is not clear if this would be needed or whether the CE-RACH is allowed with higher threshold level than the SSB threshold. |
| Qualcomm | See comment | We agree Msg3 repetition should have a separate SSB selection threshold. However, it should be configured under RACH partition, not BWP configuration. In general, such configuration issues should be discussed in the common RACH session, which has a sub-agenda for signaling issues. |
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1. Conclusion

TBD

1. References
2. R2-2200192, Issues on coverage enhancements, Qualcomm Incorporated.
3. R2-2200207, RA Procedure Aspects, Samsung Electronics.
4. R2-2200251, Discussion on CE’s impact on UL carrier selection, OPPO.
5. R2-2200269, Considerations on requesting Msg3 repetition, NEC Corporation.
6. R2-2200272, Remaining issues related to coverage enhancement, Xiaomi.
7. R2-2200421, Consideration on RAN2 impacts of Msg3 repetition, CATT.
8. R2-2200603, Remaining issues on Msg3 repetition in CE, ZTE Corporation, Sanechips.
9. R2-2201177, Further Discussion on RAN2 Impacts of Msg3 Repetition, vivo.
10. R2-2201426, Remaining issues for supporting Msg3 repetition, LG Electronics Inc.
11. R2-2201554, RNTI collision problem for Rel-17 features, Ericsson.
12. R2-2201590, RAN2 aspects for Coverage Enhancement, Nokia, Nokia Shanghai Bell.
13. R2-2201598, On Type A PUSCH repetitions for Msg3, Ericsson.
14. R2-2201617, Remaining issues on RAN2 support of Msg3 PUSCH repetition, Huawei, HiSilicon.