**3GPP TSG-RAN WG2 Meeting #117 electronic  *R2-220xxxx***

**Online, Feb 21st – Mar 3rd 2022**

**Agenda item: 9.1.3**

**Source: ZTE (email discussion rapporteur)**

**Title: Report of [Pre117-e][301][NBIOT/eMTC R17] NB-IoT carrier selection (ZTE)**

**Document for: Discussion and Decision**

# Introduction

This document is the report of the offline email discussion “*[Pre117-e][301][NBIOT/eMTC R17] NB-IoT carrier selection (ZTE)*”, as indicated below:

* *[Pre117-e][301][NBIOT/eMTC R17] NB-IoT carrier selection (ZTE)*

***Deadline:*** *Monday 2022-02-14 23:59 UTC.*

The document would collect structured company inputs and give proposals for the open issues of the coverage level-based paging carrier selection topic in R17 NB-IoT.

# Contact information

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# Discussion

The agreements achieved in RAN2#116bis e-meeting are listed below for reference:

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| **Agreements [Online]**   * *UE can be enabled/disabled coverage-based paging carrier selection via dedicated signalling. Presence or absence of the coverage information can be implicit enable/disable indication.* * *In SIB, the value range for Rmax (npdcch-NumRepetitionPaging) in R17 paging carrier (list) configuration can be ENUMERATED {r1, r2, r4, r8, r16, r32, r64, r128}.* * *In SIB, coverage specific nB is supported, e.g., a common nB value is configured for the R17 paging carrier(s) with same Rmax (npdcch-NumRepetitionPaging).* * *Coverage-specific default DRX cycle is not supported.* * *Working assumption: In SIB, coverage specific ue-SpecificDRX-CycleMin is supported, e.g., a common ue-SpecificDRX-CycleMin value is configured for the R17 paging carrier(s) with same Rmax (npdcch-NumRepetitionPaging).*   + *(FFS check whether there are any issues with the UE specific minimum DRX cycle per coverage level, can confirm WA if no issues.)* * *Paging weight can still be used in coverage-based paging carrier selection.* * *In SIB, both non-mixed operation mode and mixed operation mode can be supported in R17 paging carrier list configuration. They can be configured separately (as legacy).* * *The extension in SIB22-NB can be used for providing R17 paging carrier list configuration.* * *No “offset” (headroom) would be introduced for the configured NRSRP threshold.* * *A configurable cell specific timer period can be applied when UE compares its serving cell NRSRP with the NRSRP threshold. FFS how to signal and value range.* * *It’s specified that UE does not switch paging carrier if it has stayed less than [xx] seconds on the carrier or within a PTW. FFS value of [xx] seconds* * *Coverage based paging carrier selection is enabled implicitly, i.e., when relevant parameters are provided to the UE during release.* * *The Rel-17 paging carriers can also be used as the DL carriers for random access.* * *No need to introduce a subgroup of paging carriers for the more easily changed CE level.* * *In SIB, at most 2 coverage levels can be configured in R17 paging carrier list, each coverage level has one NRSRP threshold* * *Rmax may be configured per carrier or per carrier group (coverage level).* * *A paging carrier group index, e.g., the index to one of the two lists which correspond to the 2 coverage levels in SIB, is provided to the UE in dedicated signaling (when UE is released to idle).* * *UE measured NRSRP can be reported to network for assisting the network to provide suitable coverage level related information. FFS how.* * *FFS whether to introduce a new paging carrier list, e.g., DL-ConfigCommon-NB-r17, or just to extend PCCH-ConfigList-NB.* * *FFS whether to send LS to RAN3 (at the start of the next meeting)* |

## Open Issue 1: UE specific minimum DRX cycle

During “*[Post116-e][311] NB-IoT carrier selection* (R2-2200030)” email discussion, this issue has been discussed in details. Based on companies’ inputs, a proposal is given that “*In SIB, coverage specific ue-SpecificDRX-CycleMin is supported*”.

During the online discussion in RAN2#116bise, some companies are not sure whether coverage specific *ue-SpecificDRX-CycleMin* is needed. Moreover, in the 36.331 running CR under discussion (“*[Post116-e][316]*”), based on the company’s contribution, a kind of carrier specific parameter, e.g., *carrier-SpecificDRX-CycleMin-r17* has been mentioned in the ASN.1.

**Q1: Companies are invited to provide your preference on the following options for UE specific minimum DRX cycle and please elaborate the reasons for your choice (Please note the exact naming can be discussed later):**

* **Option 1:** to introducea new *ue-SpecificDRX-CycleMin* which is configured per coverage level
* **Option 2:** to introduce a new *ue-SpecificDRX-CycleMin* which is configured per R17 paging carrier
* **Option 3:** no new parameter for *ue-SpecificDRX-CycleMin*. That mean legacy cell specific*ue-SpecificDRX-CycleMin* would be used.

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| **Company** | **Option** | **Comment** |
| ZTE | Option 1 | According to TS 36.304, the usage of *ue-SpecificDRX-CycleMin* in R16 is that: T = min (default DRX value, max (UE specific DRX value, minimum UE specific DRX value broadcast in system information)).  Per our understanding, the configuration of *ue-SpecificDRX-CycleMin* can be smaller than the default DRX cycle of the cell and it need to be consistent with the paging resources density and the maximum paging repetitions of the cell:   * For a UE with small UE specific DRX value, in order to avoid CSS overlapping, the UE specific DRX value may not be directly used for T calculation. The small UE-specific DRX cycle needs to be "corrected" by such process that max (UE specific DRX value, minimum UE specific DRX value broadcast in system information). This would result in that, in some cases, the small UE specific DRX cycle is no longer used and *ue-SpecificDRX-CycleMin* would be used to compare with other cycles. In this way, CSS overlapping can be avoided.   After CEL-based paging carrier selection is supported, at most two R17 paging carrier groups (corresponding to two coverage levels) would be configured which are assumed to be used by UE in good or middle coverage situation. We have agreed that, for each paging carrier group corresponding to each coverage level, the carriers in it can have a common *nB* value configuration. That means, these carriers could be configured with denser paging resources, less repetitions and therefore can accommodate more pagings. Therefore, we think a coverage specific *ue-SpecificDRX-CycleMin* is needed which can be adapted to the paging resource density and the paging repetitions of each paging carrier group. We see no necessity or benefit to provide carrier specific *ue-SpecificDRX-CycleMin.*  DuringRAN2#116bise discussion, company has mentioned this parameter is not needed as it cannot be known by core network, hence CN’s paging strategy may not take full advantage of UE specific DRX cycle. We are not so sure about the issue (even if there is an issue, it exists from R16). We think core network anyway can send a paging to the eNB, mainly according to the actual arrival of the DL service and the paging cycles it knows about. The main usage of *ue-SpecificDRX-CycleMin* is in eNB, e.g., for optimized scheduling of paging in air interface. Therefore, it has no intention to let core network know this information. The only possible issue may be that eNB may need to cache some pagings for a while. We think this is acceptable in the case that required repetitions are large. |
| **Qualcomm** | Option 1 | Don’t see a major use-case to have a carrier specific minimum DRX cycle hence a coverage specific DRX cycle is sufficient.  We also propose to limit the value range to 320, 640, 1280 and 2560ms. |
| **Huawei, HiSilicon** | Option 1 | We agree that the issue exists in R16, i.e. the CN does not know via S1/NG-AP what is the minimum UE specific DRX supported in the cell and whether it is supported at all, still this van be known via OAM. If the MME does not know, then it may retransmit paging too early, possibly even before the first page has been delivered.  If we have UE specific DRX min per carrier in R717, in the MME does not know, this is kind if improvement to R16. If the MME knows by OAM, then the UE may monitor more that needed, but this is not a big issue. |

## Open Issue 2: Time duration for UE staying on a paging carrier

RAN2 has agreed “*UE does not switch paging carrier if it has stayed less than [xx] seconds on the carrier or within a PTW*”. Not only the value of [xx] seconds but also the details of UE behavior need to be further discussed and decided.

**Q2a: Companies are invited to provide comments on whether the UE needs to wait [xx] seconds or skip paging carrier switching in PTW in both of the following cases or in only one case:**

* + **Case 1: After selecting R17 paging carrier**
  + **Case 2: After fallback to legacy paging carrier**

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| **Company** | **Case** | **Comment** |
| ZTE | Only Case 1 | We think the main purpose of introducing [xx] seconds or skipping paging carrier switching in PTW is try to avoid ping-ping between different paging carriers and try to reduce the inconsistence between UE and network. So it’s acceptable to us to keep the UE on the selected R17 paging carrier for a while ([xx] seconds), as long as possible. We think conservative setting of NRSRP threshold for each paging carrier group would be already helpful for this purpose. And such [xx] seconds may give a bit more help but the help is limited.  However, after UE fall back to a legacy paging carrier due to deterioration of radio quality, as the eNB still starts trying paging on the selected R17 paging carrier, this will inevitably lead to the failure of the first paging. In such case, we think the most suitable process is to let UE keep the suitability checking before each PO. Once the suitability checking is fulfilled, the UE should return to the assigned coverage level and select a R17 paging carrier as soon as possible. Therefore, it’s better that UE keeps suitability checking after UE fall back to a legacy paging carrier, e.g., no need to apply this [xx] seconds in this case. |
| Qualcomm | Both cases | These are two separate questions.   1. We prefer the UE uses the selected paging carrier for at least a period [x] before it switches to a different paging carrier unless UE changed cell. That is, the hysteresis can be the same whether UE selects legacy paging carrier or coverage-based paging carrier. 2. All POs within the PTW should be monitored on the same paging carrier. |
| Huawei, HiSilicon | Both cases | same views as QC |

**Q2b: Companies are invited to provide comments on how to specify that no paging carrier switching during PTW.**

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| **Company** | **Comment** |
| ZTE | We are fine with no paging carrier switching during PTW.  In legacy, UE performs paging carrier selection before each PO. We assume this is also applied to R17 CEL-based paging carrier selection. So we’d better not to touch this part of UE behaviour/process. Maybe a simple way for specifying this intention is to disable/stop suitability checking according to the NRSRP threshold (or just assume the suitability checking is always fulfilled) during PTW. |
| Qualcomm | In general, UE selects the paging carrier before it goes to sleep because UE needs to use the paging carrier specific parameters to determine when the next PO is.  We don’t think it would be too complicated to specify that UE uses the same paging carrier for all POs it monitors during the PTW. |
| Huawei, HiSilicon | We do not think that in legacy the UE performs carrier selection before each PO. There is nothing random about it. UE only needs to do it once when acquiring SIB22 or after S-TMSI reallocation  we also do not think it is difficult to specify that the UE does not switch carrier within a PTW |

**Q2c: Companies are invited to provide comments on how to specify such [xx] seconds, e.g., whether it needs to specify a kind of timer with [xx] seconds? If yes, what’s the conditions for timer start/restart/stop?**

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| **Company** | **Comment** |
| ZTE | We understand [xx] seconds would be mainly applied to the case that eDRX is not configured.  Similar as that for skipping paging carrier switching in PTW, a simple way of implementing this [xx] seconds may be that, after UE selects a R17 paging carrier, UE just stop suitability checking for [xx] seconds. After that, UE can perform suitability checking once, if fulfilled, UE would stay at the current R17 paging carrier and start waiting for another [xx] seconds. |
| Qualcomm | The timer can be in units of DRX cycles.  Start timer: When UE switches between legacy paging carrier and coverage-based paging carrier list.  Timer expiry: UE may change paging carrier list depending on the serving cell condition.  While Timer is running: Re remains on the last selected carrier.  Timer stopped: Upon entry to RRC\_CONNECTED state, and upon cell reselection. |
| Huawei, HiSilicon | we think that [XX] in seconds could be used for all cases that we have for cell reselection, |

**Q2d: Companies are invited to provide comments on what’s the suggested value of [xx], xx seconds or value in units of DRX/eDRX cycle? Is it configurable or hard-coded?**

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| **Company** | **Comment** |
| ZTE | For simplicity, we think such [xx] seconds can be hard-coded, e.g., 20.48 seconds or 2 maximum DRX cycles.  Configurable way is also acceptable to us. |
| Qualcomm | The minimum period [xx] for which UE remains on one paging carrier should be configurable and in units of DRX cycle e.g., 1, 2, 4, 8. |
| Huawei, HiSilicon | we propose to have the value configurable in sec |

**Q2e: Any other issues for such [xx] seconds?**

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| **Company** | **Comment** |
| Qualcomm | Consider the case UE enters RRC\_IDLE from RRC\_CONNECTD and dedicated signalling provided coverage-based paging carrier index. In this case should UE select paging carrier according to the carrier index or should UE remain on the same paging carrier as it was using before in entered RRC\_CONNECTED state at least for a period [xx].  This is why we think just because the UE sent serving cell measurement report is not sufficient to use the coverage-based paging carrier. |
| Huawei, HiSilicon | We think that UE after being released can assume a priori the assigned coverage level. |
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## Open Issue 3: UE report

RAN2 has agreed that *UE measured NRSRP can be reported for assisting the network to provide suitable coverage level related information.* It’s still FFS on the detailed report way.

During “*[AT116bis-e][301][NBIOT/eMTC R17] Carrier Selection* (R2-2201786)” email discussion, more companies (6/9) prefer the simple way, e.g., the **Option 1**. At the same time, some other companies think this is not enough and prefer **Option 2** below:

* **Option 1:** to make legacy Msg5 report mandatory.
* **Option 2:** to report an indication on whether the existing CQI report is suitable for coverage-based paging carrier selection.

**Q3: Companies are invited to provide your preference on the above options for the UE report and please elaborate the reasons.**

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| **Company** | **Option** | **Comment** |
| ZTE | Option 1 | We think Option 1 is clear and enough.  We are not clear about the details of the Option 2, e.g., is it a simple indication (e.g., “Yes” for suitable and “No” for unsuitable) or some other mapping format? When to send such indication? Also in Msg5 or during the connection?  Proponent company of Option 2 is invited to provide more details of the usage and details (e.g., when to report and what’s the report format) of Option 2**.** |
| Qualcomm | Option 2 | We think for reliable operation of this feature either make the serving cell measurement reporting conditional on the UE having been on a paging carrier at least for a period [xx], or add an indication that indicates the UE has been on the current paging carrier at least for a period [xx] hence it is reliable enough for network to use this for coverage-based paging carrier group selection. |
| Huawei, HiSilicon | Not option 2. | Option 1 is not absolutely necessary. eNB can ask the UE to report the CQI during the connection.  If the UE cannot provide any of them then the eNB eventually does not assign a coverage level |

## Open Issue 4: ASN.1 structure for paging carrier configuration in SIB

RAN2 has agreed most needed IEs for the R17 paging carrier list configuration in SIB. But how to organize the IEs in ASN.1 are still FFS.

More details can be left to TS 36.331 running CR discussion, but before that, as rapporteur, we want to suggest that companies can firstly decide the high level direction, e.g., make choice between the below **Approach 1** and **Approach 2**. Please note the details of **Approach 1** and **Approach 2** have already been described in the on-going TS 36.331 running CR (“*[Post116bis-e][316]*”):

* **Approach 1:** just to extend *PCCH-ConfigList-NB*
* **Approach 2:** to introduce a new R17 paging carrier list

**Q4: Companies are invited to provide your preference on the above approach for ASN.1 structure for paging carrier configuration in SIB and please elaborate the reasons for your choice.**

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| **Company** | **Approach** | **Comment** |
| ZTE | Approach 1 | As background, in legacy, a DL non-anchor carrier can be used as paging carrier or RAR carrier. The configuration for paging carrier (with ***pcch-Config***) or RAR carrier (with the npdcch related configuration in ***NPRACH-Parameters-NB***) are separated. For example, the RAR carrier configuration is as below:  NPRACH-Parameters-NB-r14 ::= SEQUENCE {  nprach-Parameters-r14 SEQUENCE {  nprach-Periodicity-r14 ENUMERATED {ms40, ms80, ms160,  ms240, ms320, ms640, ms1280, ms2560} OPTIONAL, -- NEED OP  //skip//    npdcch-NumRepetitions-RA-r14 ENUMERATED {r1, r2, r4, r8, r16, r32, r64, r128, r256, r512, r1024, r2048, spare4, spare3, spare2, spare1} OPTIONAL, -- NEED OP  npdcch-StartSF-CSS-RA-r14 ENUMERATED {v1dot5, v2, v4, v8, v16, v32, v48, v64} OPTIONAL, -- NEED OP  npdcch-Offset-RA-r14 ENUMERATED {zero, oneEighth, oneFourth, threeEighth}OPTIONAL, -- NEED OP  //skip//  npdcch-CarrierIndex-r14 INTEGER (1..maxNonAnchorCarriers-NB-r14) OPTIONAL, -- Need OP  ...  } OPTIONAL -- Need OR  }   |  | | --- | | ***npdcch-CarrierIndex***  For FDD: Index of the carrier in the list of DL non anchor carriers. The first entry in the list has index '1', the second entry has index '2' and so on.  If the UE supports mixed operation mode and *dl-ConfigListMixed* is present in *systemInformationBlockType22-NB*, the UE creates a combined list of DL carriers for random access by appending *dl-ConfigListMixed* to the *dl-ConfigList* while maintaining the order among both *dl-ConfigList* and *dl-ConfigListMixed*; only the first *maxNonAnchorCarriers-NB-r14* DL non-anchor carriers in the concatenated list can be used for random access.  If the field is absent in the entry in *nprach-ParametersListEDT* in *SystemInformationBlockType22-NB*, the value of *npdcch-CarrierIndex* in the corresponding entry of *nprach-ParametersList* applies, if present. If the field is absent in an entry in *nprach-ParametersListFmt2EDT* in *SystemInformationBlockType23-NB*, the value of *npdcch-CarrierIndex* in the corresponding entry of *nprach-ParametersListFmt2* applies, if present. Otherwise, the DL anchor carrier is used.  For TDD: This parameter is absent and the same carrier is used in uplink and downlink. | | ***npdcch-NumRepetitions-RA***  Maximum number of repetitions for NPDCCH common search space (CSS) for RAR, Msg3 retransmission and Msg4, see TS 36.213 [23], clause 16.6.  See NOTE. | | ***npdcch-Offset-RA***  Fractional period offset of starting subframe for NPDCCH common search space (CSS Type 2), see TS 36.213 [23], clause 16.6.  See NOTE. |   If we introduce a new R17 paging carrier list as that *cbpcg-PCCH-ConfigList-r17* and *cbpcg-PCCH-ConfigMixedList-r17* in **Approach 2** in TS 36.331 running CR, we think we need to clarify whether “the list of DL non anchor carriers” in the definition of ***npdcch-CarrierIndex*** can include the new R17 DL paging carrier list? Per our understanding for the current **Approach 2**, it seems a pure paging carrier list would be introduced, that cannot be used for RAR. We think this is undesired and not aligned with the legacy rule for non-anchor carrier configuration.  Conversely, the main rule of **Approach 1** is that a DL non-anchor carrier can be configured with R14 paging resources or R17 paging resources. With this way, we can try to make the R17 paging carrier configuration has as little impact on the existing non-anchor carrier configuration as possible. Moreover, in our assumption, the legacy UE is still allowed to use the carriers in R17 paging carrier list as the RAR carriers. Meanwhile, the R17 UE is also allowed to use the carriers in the legacy paging carrier list as the RAR carriers. This is feasible with **Approach 1.**  Therefore, we prefer **Approach 1.** We have some clarifications for **Approach 1**, those are not discussed here and will be provided in 36.331 running CR review. |
| Qualcomm | Approach 2 preferred | In principle both options can technically work.  Conceptually Approach 2 is easier for the reader to understand. Note, when (G)WUS was introduced it made sense to just extend pcch-Config-r14 because (G)WUS was an additional parameter, it did not replace the existing parameters. With coverage-based paging carriers, not only there are more parameters to configure but the parameter values are expected to be different from those configured in pcch-Config-r14.  ASN.1 corresponding to the current agreements is provided in the running CR for both approaches. We think it is much easier to discuss this aspect as part of the running CR because reader can see how two options look. |
| Huawei, HiSilicon | Approach 1 preferred | We think that both approaches work an , based on the draft running CR, we think there is little difference between the two options both in terms of signalling overhead and complexity. In approach 1, we need to link the carrier to a paging carrier group index. In approach 2, we need to link the paging carrier group to a paging carrier index.  Now, conceptually, we have a preference for option 1 as it aligns with the legacy approach to have a list of DL carriers and their associated functionalities. With approach 2, we have an orthogonal approach. i.e. a functionality with the associated carriers |

## Open Issue 5: RAN3 impacts

In the previous meeting discussion and in the contributions, it has been mentioned that the assigned information to UE in dedicated signaling, e.g., the paging carrier group index, may also need to be delivered to core network and further sent back to eNB in next time paging.

**Q5a: Companies are invited to provide your comments on whether the assigned information to UE in dedicated signaling also need to be delivered to core network and sent back to eNB in next paging?**

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| **Company** | **Yes/No** | **Comment** |
| ZTE | Yes | We think the assigned information to UE in dedicated signaling also need to be delivered to core network and sent back to eNB in next paging.  The purpose is to make target eNB aware that the related UE is using CEL-based paging carrier selection scheme and make the target gNB exactly know the coverage level that the UE is using. Then the target eNB can apply the same R17 paging carrier selection scheme to send paging in air interface. |
| Qualcomm | Yes | It absolutely necessary for network to remember the coverage-based paging carrier index signalled to the UE. Otherwise the feature would not work reliably. |
| Huawei, HiSilicon | Yes |  |

Per rapporteur’s knowledge, RAN3 has had some related discussion but no agreement can be achieved. It seems the following options have been discussed in RAN3, for delivering the assigned information to UE in dedicated signaling to core network and sent back to eNB:

* **Option 1:** in *UEPagingCoverageInformation* RRC container. This means RAN2 change.
* **Option 2:** in S1/NG signaling, e.g., in *Cell Identifier and Coverage Enhancement Level* IE in TS 36.413 and in *Paging Assistance Data for CE Capable UE* IE in TS 38.413. This means RAN3 change.

**Q5b: If the answer to Q5a is yes, companies are invited to provide your preference on the following Options:**

* **Option 1:**
* **Option 2**
* **Other option**

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| **Company** | **Yes/No** | **Comment** |
| ZTE | Option 2 | We think explicit inclusion of the assigned information to UE in RAN3 signaling (**Option 2**) would be clearer.  If we go for **Option1**, it may need to explicitly describe that the paging carrier group index can only be included in the *UEPagingCoverageInformation* only if it is provided to the UE in the release message.  No matter we go for **Option 1** or **Option 2**, we think we’d better to send LS to RAN3 as soon as possible to let them know our choice. |
| Qualcomm | Option 1 | The coverage-based paging carrier group index is only used by the cell that signalled it to the UE. When paging the UE not only this index but also the coverage-information useful.  It is true the current SA2 specific (wrongly in our view) prevents the CN from providing coverage information for UE with restricted-coverage but there are no such restrictions in RAN2 or RAN3 specifications.  In our view option 2 is not justified.  As RAN3 has sent an LS to RAN2, RAN2 should provide response even if there is no impact to RAN3 specification. |
| Huawei, HiSilicon | Option1 | Option 1 seems the quite obvious solution from RAN2 point of view. We agree with QC that the current restriction in SA2 is not correct but even if it was, it is not needed.  We also agree that we need to reply to RAN3 LS whatever RAN2 decision. |

## Other issue

**Q6: Companies are invited to indicate whether there is any other issue for CEL-based paging carrier selection?**

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| **Company** | **Comment** |
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| Qualcomm | Combination of the following two agreement seems to cause confusion:   * In SIB, coverage specific nB is supported, e.g., a common nB value is configured for the R17 paging carrier(s) with same Rmax (npdcch-NumRepetitionPaging). * Rmax may be configured per carrier or per carrier group (coverage level).   It is clear all coverage-based paging carriers for one coverage level can have same or different Rmax values. But this also implies nB can also be same or different for all coverage-based paging carriers for one coverage level. **It would be good to confirm that nB can be different for each coverage-based paging carriers for one coverage level.** |
| Huawei, HiSilicon | We agree that we need to reconfirm the agreement but in our view it is fine to have it per paging carrier group, same a UE-specific-DRX-min. Note that nB is not so much related to Rmax but mostly to the DRX cycle. |

# Conclusion

TBD

# References

[1] R2-2200030, Report of [Post116-e][311] NB-IoT carrier selection (ZTE), RAN2#116bise

[2] R2-2201786, Report of [AT116bis-e][301][NBIOT/eMTC R17] Carrier Selection (ZTE), RAN2#116bise

[3] R2-2201795, Report of [310] Carrier selection open issues (ZTE), RAN2#116bise