3GPP TSG-RAN WG2 #116-e Tdoc R2-211xxxx

Electronic meeting, 1st – 12th November 2021

Agenda Item: 8.12.2.2

Source: Ericsson (Rapporteur)

Title: Report - Using NCD-SSB instead of CD-SSB for RedCap UEs

Document for: Discussion, Decision

# 1 Introduction

RAN1 sent an LS to RAN2 and RAN4 on use of NCD-SSB instead of CD-SSB in [R2-2110727](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_116-e/Docs//R2-2110727.zip). RAN1 discussed the following options related to configuration and use of DL BWPs for RedCap:

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| * **For FR1, following options:**   + **Option 1:**     - **For a separate initial DL BWP (if it does not include CD-SSB and the entire CORESET#0),**       * **RedCap UE does NOT expect it to contain SSB/CORESET#0/SIB.**     - **For an RRC-configured active DL BWP (if it does not include CD-SSB and the entire CORESET#0),**       * **RedCap UE does NOT expect it to contain SSB/CORESET#0/SIB.**   + **Option 2:**     - **For a separate initial DL BWP (if it does not include CD-SSB and the entire CORESET#0),**       * **If it is configured for random access while not for paging in idle/inactive mode, RedCap UE does NOT expect it to contain SSB/CORESET#0/SIB.**         + **FFS: For BWP#0 configuration option 1, whether the UE can expect SSB transmission in the separate initial DL BWP when it is used in connected mode.**       * **If it is configured for paging, RedCap UE expects it to contain NCD-SSB for serving cell but not CORESET#0/SIB.**     - **For an RRC-configured active DL BWP in connected mode (if it does not include CD-SSB and the entire CORESET#0),**       * **RedCap UE expects it to contain NCD-SSB for serving cell [FFS: or CSI-RS or measurement gap configuration] but not CORESET#0/SIB.**   + **Note: if a separate initial/RRC configured DL BWP is configured to contain the entire CORESET#0, CD-SSB is expected by RedCap UE.**   + **Note: The network may choose to configure SSB or MIB-configured CORESET#0 or SIB1 to be within the respective DL BWP.**   + **FFS: For Option 1 and Option 2, whether RedCap UE can/cannot expect SSB under certain other conditions, e.g., for SSB monitoring periodicity (i.e., SMTC configuration) and DRX cycle**   + **FFS: Whether additional mechanism for SI update or how SI update notifications and/or SI updates are signaled to RedCap UEs**   + **FFS: FR2 case** |

The rest of the LS asks for RAN2 and RAN4 feedback on the following questions:

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| RAN1 respectfully requests RAN2 and RAN4 to provide feedback about the use of NCD-SSB instead of CD-SSB in terms of functionality feasibility, performance/coexistence, and specification/implementation impacts (when applicable) for idle/inactive/connected mode procedures for serving and non-serving cells for a Rel-17 RedCap UE operating with an initial or non-initial DL BWP not containing CD-SSB. Specifically, RAN1 would like RAN2/RAN4 to respond to the following questions before the RAN1#107-e meeting:   1. [RAN2/4] whether it is feasible to use NCD-SSB for serving and non-serving cell measurements for idle, inactive, and/or connected mode for all or some of RRM, RLM, BFD, link recovery, RO selection, mobility, time/frequency tracking and AGC 2. [RAN2/4] whether it is feasible to use NCD-SSB as QCL source of other DL channels/signals and as spatial relation (for UL channels/signals) transmitted in idle, inactive, and/or connected mode in the initial/non-initial DL BWP of RedCap UE 3. [RAN2] whether/when the PCIs indicated by the NCD-SSB and CD-SSB can be the same/different, if both NCD-SSB and CD-SSB are transmitted on the serving cell of RedCap UE 4. [RAN2/4] whether/when periodicities and/or TX power and/or block indexes (provided by *ssb-PositionsInBurst* in SIB1 or in *ServingCellConfigCommon*) and/or QCL sources of NCD-SSB can be same/different from those of CD-SSB, if both NCD-SSB and CD-SSB are transmitted on the serving cell of RedCap UE 5. [RAN2/4] whether it is necessary to introduce configuration limitations for NCD-SSB (e.g., regarding frequency locations, periodicity), e.g., to ensure coexistence with legacy UEs 6. [RAN2/4] if CD-SSB is not transmitted in the non-initial DL BWP of RedCap UE, whether it is feasible to transmit periodic CSI-RS for UE to use as an alternative of SSB in the non-initial BWP of RedCap UE or rely on UE performing RF retuning as in measurement gap outside active BWP for BWP without SSB nor CORESET#0 operation 7. [RAN2/4] whether it is feasible for a RedCap UE to retune to a CD-SSB rather than use an NCD-SSB of larger periodicity 8. [RAN2/4] any other potential impacts identified by RAN2/4 on support NCD-SSB for measurement   In order for the RAN1 work within the Rel-17 RedCap WI to be finalized in December 2021 as expected, RAN1 would need responses from RAN2 and RAN4 already before RAN1#107-e, which starts 11th November 2021. |

This offline discussion is to summarize the Tdocs listed below with an intention to come up with a list of proposals that are agreeable during the related online discussion and a list of proposals that require further discussion during the related online session.

* [1] [R2-2109576](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_116-e/Docs//R2-2109576.zip), Definition and reduced capabilities for RedCap UE, and NCD-SSB related LS, Huawei, HiSilicon
* [2] [R2-2109741](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_116-e/Docs//R2-2109741.zip), Discussion on NCD SSB and UE type for RedCap UEs, vivo, Guangdong Genius
* [3] [R2-2109448](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_116-e/Docs//R2-2109448.zip), Reply LS on use of NCD-SSB instead of CD-SSB for RedCap UE, Qualcomm Incorporated
* [4] [R2-2109451](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_116-e/Docs//R2-2109451.zip), NCD-SSB and RedCap-specific BWPs, Qualcomm Incorporated
* [5] [R2-2110095](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_116-e/Docs//R2-2110095.zip), Making ND-SSB work for RedCap in Rel-17, Apple
* [6] [R2-2110773](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_116-e/Docs//R2-2110773.zip), Use of NCD-SSB instead of CD-SSB for RedCap UEs, Ericsson

# 2 Discussion on proposed replies to RAN1’s questions

## 2.1 Question 1

**Q1:** [RAN2/4] whether it is feasible to use NCD-SSB for serving and non-serving cell measurements for idle, inactive, and/or connected mode for all or some of RRM, RLM, BFD, link recovery, RO selection, mobility, time/frequency tracking and AGC

The following arguments/proposed replies have been provided in the Tdocs addressing the LS from RAN1:

* In [1], it is indicated that current specifications only support CD-SSB based measurements, e.g., RRM of serving cell and neighbouring cell and mobility, regardless of whether it is RRC\_CONNECTED or RRC\_IDLE/RRC\_INACTIVE states. It is also stated that it is not clear from RAN2 standpoint if RLM/BFD/link recover are feasible /suitable, considering that NCD-SSB may have larger period or different TX power; so this may require an evaluation in RAN1 and RAN4. Similarly, UE chooses RACH resource associated to one SSB index based on CD-SSB measurement results and network needs to response RAR at the spatial direction of this SSB index in current spec. Since NCD-SSB and CD-SSB may have different TX power and block indexes, it is unclear from RAN2 standpoint how RACH resource is chosen when UE performs NCD-SSB. The contribution claims that time/frequency tracking and AGC are out of RAN2’s scope.
* In [2], it is captured that that it is feasible to use NCD-SSB for serving and non-serving cell measurements for idle, inactive, and/or connected mode for all or some of RRM, RLM, BFD, link recovery, RO selection, mobility, time/frequency tracking and AGC.
* In [3] and [4], it is stated that from RAN2 standpoint it is feasible to use NCD-SSB for serving and non-serving cell measurements for idle, inactive, or connected mode for all of RRM, RLM, BFD, link recovery, RO selection, mobility, time/frequency tracking and AGC, if the NCD-SSB is transmitted by UE’s serving cell with the same SCS and at the same power level as the CD-SSB, and QCL’ed with the CD-SSB of UE’s serving cell.
* In [5] it is mentioned that It is feasible to adapt NCD-SSB for RedCap in general and the specification impact from RAN2 perspective can be kept to a minimum if the NCD-SSB has the same configuration as the CD-SSB (except for being in a different frequency) in terms of SSB burst/beam index and configuration and QCL information/derivation.
* In [6], idle and inactive modes and connected mode is considered. For the former, it is stated that the concept of (non-)cell-defining NCD-SSBs and the corresponding procedures such as measurements, cell (re-)selection do not exist in the current RAN2 specifications. Informing idle and inactive UEs about an additional "NCD-SSB" in the region of the "RedCap initial DL BWP" (at the edge of the carrier) by an addition in SIB1 would be relatively simple and feasible, however using NCD-SSB for measurements and cell (re-)selection would require substantial changes to signalling and anyway require the UE to re-tune to the CORESET#0 for reading SIBs. It is claimed in the contribution that NCD-SSB based RRM measurements are not currently supported, but NCD-SSB can already be configured for RRM in RRC\_CONNECTED.

It is also explained that current RRC signalling allows configuring SSB-based RRM measurements on any (CD- or NCD-) SSB whereas the current RRC signalling does not allow using an NCD-SSB for RLM, BFD, link recovery, RO selection, mobility, in TCI-states or for any other functionality (other than RRM measurements).It would be feasible and simple to inform the UE about the ARFCN of an NCD-SSB which it shall use instead of the CD-SSB for RLM, BFD, in TCI states, for RO selection and for all other purposes that otherwise use the CD-SSB.

In summary; in [2], [3], [4], and [5] it is claimed that it is feasible to use NCD-SSB for serving and non-serving cell measurements for idle, inactive, or connected mode for all of RRM, RLM, BFD, link recovery, RO selection, mobility, time/frequency tracking and AGC if the NCD-SSB is transmitted by UE’s serving cell with the same SCS and at the same power level as the CD-SSB, and QCL’ed with the CD-SSB of UE’s serving cell. On the other hand, even though it is considered in [1] and [6] that informing idle and inactive UEs about an additional “NCD-SSB” in the region of the “RedCap initial DL BWP” would be feasible concerns have been mentioned regarding idle/inactive mode RRM measurements and mobility if NCD-SSB is used. The authors claim that using NCD-SSB for measurements and cell (re-)selection would require substantial changes to signalling and anyway require the UE to re-tune to the CORESET#0 for reading SIBs.

A1.1 Do you agree that in idle and inactive modes, the concept of non-cell-defining SSB (NCD-SSB) and corresponding procedures (measurements, cell (re-)selection) do not exist in the current RAN2 specifications and thus using NCD-SSB for measurements and cell (re-)selection would require substantial changes to signalling and anyway require the UE to re-tune to the CORESET#0 for reading SIBs? Please elaborate your reply.

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| **Company** | **Yes/No** | **Comments** |
| MediaTek | ?? | There are multiple questions above, so answering them individually   1. Measurement procedures based on NCD-SSB do not currently exist? Yes 2. Substantial signaling changes needed? No 3. UE need to retune for reading SIB? Yes   The reason for the introduction of NCD-SSB for these procedures is to enable RedCap UEs to be able to function without the need for constant retuning between the BWP where CD-SSB is location and the BWP it is currently operating on. While most background maintenance procedures are based on the CD-SSB today, it is simple enough to introduce the necessary signaling changes to do so based on a NCD-SSB (and it is RAN2’s job to provide necessary signaling support for features that are introduced).  Retuning for SI reception is irrelevant to this discussion, as SI reception is not a frequent occurrence (typically once at cell reselection). What needs to be avoided is frequent retuning for synchronization, RLM and RRM purposes. |
| Nokia, Nokia Shanghai Bell | Yes | Non-cell-defining SSB (NCD-SSB) and corresponding procedures (measurements, cell (re-)selection) do not exist in the current RAN2 specifications and major impact can be expected in case they would be specified. |
| Apple | ?? | NCD-SSB is also not present in CONNECTED mode. This is a new topic. We do not agree that substantial changes are needed for IDLE/INACTIVE. NCD-SSB (if configured by NW) can be used as CD-SSB, and even can be used for paging reception.  As MediaTek mentioned, SI reception is not a frequent thing, and even if CD-SSB is used for SI reception, the more often case of paging reception could be with NCD-SSB. To us it’s more a configuration issue, and does not result in a substantial change. |
| Qualcomm | See comments | It is true that use of NCD-SSB in RRC Idle/Inactive requires new signaling support (to help UE locate them). But we do not think the required change would be substantial. In fact, we think the benefits that it enables for RedCap UEs in RRC Idle/Inactive well adjust the change.  For example, consider the case in which RedCap-specific initial DL BWP is configured for paging only. UE typically needs to measure SSB of its serving cell before its PO (e.g. to track time/freq, tune its AGC, etc). If this initial DL BWP does not contain any SSB, UE has to first retune to the default initial DL BWP, measure CD-SSB there, then tune back to its RedCap-specific initial BWP to perform paging reception. Since this retuning happens every paging cycle, it would be a significant overhead and extra power consumption for RedCap UEs.  Regarding rapporteur’s comment on retuning, we do not think it is always true. For example, once signaling support for NCD-SSB in RRC Idle/Inactive becomes available, neighbor cell RRM measurements can be performed based on NCD-SSB too (see our reply to Question A1.2 too). |
| Ericsson | Yes | It would require changes yet the UE would still need to re-tune from the NCD-SSB to the CD-SSB/CORESET#0 for the purpose of updating SIBs and for reading target cells’ SIB1 upon cell reselection. |
| DENSO | No | We agree that the current specification does not support cell (re)selection based on the measurement over NCD-SSB. On the other hand, it is not clear if the substantial signaling change is required to support the NCD-SSB based cell (re)selection.  First of all, no matter how the measurement for cell (re)selection is performed, according to the RAN1 input, the following signaling extension is anyway required.   * Configuration of the separate DL BWP for RedCap UEs (e.g. via SIB1 or HO command). * Configuration of NCD-SSB if present in the separate DL BWP (e.g. ARFCN of NCD-SSB and more, if the other parameters are different from CD-SSB).   In addition, at least it has to be stated in TS 38.300 that NCD-SSB is used for RedCap UE, if NCD-SSB is present in the separate initial DL BWP.  For option 2 in the RAN1 LS, there is a scenario that RedCap UE receives paging and perform random access over the separate initial DL BWP where NCD-SSB is transmitted. In this case, once RedCap UE selects a suitable cell and is camped on a cell via the “legacy” initial DL BWP where CD-SSB, CORESET#0 and SIB1 (and onwards) are transmitted, the UE retunes to the separate initial DL BWP to monitor paging. If RedCap UE performed measurements for cell reselection over CD-SSB, RedCap UE would have to retune back and forth between NCD-SSB and CD-SSB. Therefore, for option 2 in the RAN1 LS, the serving cell measurement for cell reselection should be performed over NCD-SSB. In contrast, the neighbor cell measurement can be performed over CD-SSB as in the legacy. There is no need to do it over NC-SSB. On cell selection, the legacy mechanism can work, i.e. to perform measurements over CD-SSB.  If only random access is performed in the separate initial DL BWP and NCD-SSB is not transmitted over there, the legacy mechanism can work.  In conclusion, our opinion is summarised as follows:  For the case where RedCap UE receives paging and perform random access over the separate initial DL BWP where NCD-SSB is transmitted,  - In case of cell selection, RedCap UE performs measurements as in the legacy (i.e. over CD-SSB).  - In case of cell reselection, RedCap UE performs the serving cell measurement over NCD-SSB, whilst it performs the neighbor cell measurement over CD-SSB.  Otherwise (i.e. NCD-SSB is not transmitted over the separate initial DL BWP), the measurements for cell (re)selection is done as in the legacy (i.e over CD-SSB). |
| Huawei, HiSilicon | Yes | There may be some existing concept of NCD-SSB.  But using NCD-SSB for measurements and cell (re-)selection is not supported, which requries lots of spec impact, substantial changes to signalling.  Considering that lots of questions/issues are aksed from RAN1, we can definitely be sure the stantarnd efforts will be huge.  Whether this NCD-SSB “require the UE to re-tune to the CORESET#0 for reading SIBs“ seems RAN1 issue and not directly asked in the RAN1 LS. |
| CATT | Yes | NCD-SSB and corresponding procedures do not exist in the current RAN2 specifications.  It can be expected that using NCD-SSB for measurements and cell (re-)selection would require substantial specification change.  Assuming SIBs will only be transmitted in legacy initial DL BWP defined by CORESET#0 (a natural choice from network’s view), the UE shall re-tune to the CORESET#0 for reading SIBs. |
| Sharp | See comments | NCD-SSB concept does not exist in current RAN2 specs.  Using NCD-SSB for measurements and cell (re-)selection does not require substantial changes and is very helpful to avoid frequent retuning. |
| Xiaomi | Yes | The current specification is that UE uses CD-SSB for cell (re)selection in idle/inactive, which means the measurement is performed based on CD-SBB in idle/inactive. In our understanding, UE can perform measurements based on NCD-SSB, but when the criteria are fulfilled (e.g. R criteria), UE will retune to CD-SSB for reading SIB. |
| Spreadtrum | Yes | For measurement, for FR1, UE does not need to read PBCH payload for time index, so there is no impact to use NCD-SSB; For FR2, UE may read PBCH payload for time index, but PBCH in NCD-SSB contains time index, so there is no spec impact to use NCD-SSB, except the NCD-SSB freq postion.  For cell (re-)selection, UE needs to read MIB and SIB. UE needs perform cell (re-selection) based on CD-SSB. However, cell (re-)selection is not often, UE can perform RF retuning to complete cell (re-)selection after S-criterion is met. |

A1.2 If NCD-SSBs are introduced, do you think idle and inactive UEs should not use them for idle mode measurements and mobility? Please elaborate your reply.

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| **Company** | **Yes/No** | **Comments** |
| MediaTek | No | The purpose of introducing these NCD-SSBs is to ensure that the UE does not need to frequently retune to the CD-SSB.  Idle mode measurements and mobility procedures need to run every time the UE wakes up, i.e. it is as frequent as it gets in Idle mode. Therefore if NCD-SSBs are introduced, they should be used for measurements and mobility purposes; else it defeats the purpose of the introduction of these NCD-SSBs. |
| Nokia, Nokia Shanghai Bell | Yes | CD-SSBs should be used by idle and inactive UEs for measurements and mobility |
| Apple | No | We do not see the reason for not using. It is upto NW configuration. No need to constrict the NW. |
| Qualcomm | See comments | If NCD-SSB is available in RedCap UE’s initial DL BWP, we think it can be used for UE’s RRM measurements and cell re-/selection too (for both serving cell and neighbor cells), for the same reason that currently UE in RRC Connected already can perform RRM measurements based on either CD-SSB or NCD-SSB.  As a reference for our discussion in RAN2 -- RAN4 just agreed that “It is feasible to use NCD-SSB for serving and non-serving cell measurements for idle, inactive, connected mode for all or some RRM, RLM, BFD, link recovery, RO selection, mobility, time/frequency tracking and AGC”.  [Huawei]: The intermediate RAN4 agreement is below, i.e. “feasible with condition”. We don’t think RAN2 should just follow some intermediate R4 conclusion. RAN2 discussion should be independent from RAN2 perspective.  C:\Users\s00455255\AppData\Roaming\eSpace_Desktop\UserData\s00455255\imagefiles\46A6C566-E877-4DBD-A14E-B51A8C967C68.png |
| Ericsson | Yes | NCD-SSB should not be used for IDLE/INACTIVE mode mobility for the reasons mentioned above, i.e., in our comment for A1.1. |
| DENSO | No | As commented to A1.1, there is a scenario that the UE should be able to perform the serving cell measurement over NCD-SSB for cell reselection. |
| Huawei, HiSilicon | Yes | We are open on this (if NCD-SSS has to be introduced.)  This may depend on the spec impact. If the standard effort is huge, it can be deprioritized. |
| CATT | Yes | There is no guarantee the same performance of CD-SSB and NCD-SSB, especially for serving cell measurement. RedCap UE shall use CD-SSB in idle mode. |
| Sharp | No | We are open on using NCD-SSB for idle mode measurement and mobility. |
| Xiaomi | No | In our understanding, UE can perform measurements based on NCD-SSB, but when the criteria are fulfilled (e.g. R criteria), UE will retune to CD-SSB for reading SIB. |
| Spreadtrum | No | As mentioned in A 1.1, idle/inactive UEs can use NCD-SSB for measurement, but need to complete cell (re-)selection by CD-SSB. |

## 2.2 Question 2

**Q2:** [RAN2/4] whether it is feasible to use NCD-SSB as QCL source of other DL channels/signals and as spatial relation (for UL channels/signals) transmitted in idle, inactive, and/or connected mode in the initial/non-initial DL BWP of RedCap UE

**Summary of Tdocs:**

* [1] and [6] mention that QCL discussion is not in RAN2 scope. [6] mentions that it is currently not supported in terms of signalling but could be added (see Q1) if considered feasible/necessary by RAN1/4.
* In [2] no limitation from RAN2 point of view has been mentioned but it is considered that this would finally be up to RAN1 to determine.
* In [4] it is indicated as feasible if NCD-SSB is fully QCL’d with CD-SSB of the serving cell whereas [5] shares the view that it is feasible from RAN2 point of view if the properties are shared.

A2.1 Do you think it is feasible if NCD-SSB is fully QCL’d with CD-SSB of the serving cell? Please elaborate your reply.

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| **Company** | **Yes/No** | **Comments** |
| MediaTek | Yes | From a RAN2 perspective, we consider it to be feasible to use NCD-SSB as QCL source of other DL channels/signals and as spatial relation (for UL channels/signals) transmitted in idle, inactive, and/or connected mode in the initial/non-initial DL BWP of RedCap UE, if the NCD-SSB is fully QCL’d with the CD-SSB. |
| Apple | Yes | We do not see why not. |
| Qualcomm | Yes | If NCD-SSB is fully QCL’ed with CD-SSB of the serving cell (i.e. each pair of beams with the same beam index in NCD-SSB and CD-SSB are QCL’ed), we don’t see any issues for using NCD-SSB as the QCL source of other DL channels and signals.  Some signaling change may be needed to support it, but we do not think the required change would be substantial (see related section in either [4] or [6]). |
| Ericsson | N/A | RAN2 cannot decide whether and upon which assumptions it is possible to use a NCD-SSB as QCL source. This is for RAN1 and RAN4 to decide.  But RAN2 could reply: “The current signalling does not support it but it would be feasible to inform IDLE, INACTIVE and CONNECTED UEs about a NCD-SSB”. |
| DENSO | Yes for DL  No for UL | Although functional feasibility should be analysed and decided by RAN1/4, RAN2 can express the view from RRC configuration viewpoints. According to the existing configuration of QCl-Info, the serving cell index, BWP ID, reference signal (CSI-RS or SSB) and QCL type can be configured. Suppose that CD-SSB and NCD-SSB are transmitted over the different BWPs, the UE can learn if the SSB as QCL resource is CD-SSB or NCD-SSB by obtaining BWP ID. This is based on the assumption that BWP ID is different between the “legacy” initial DL BWP and the separate initial DL BWP for RedCap UE.  In contrast, for spatial relation for UL channels/signals, if SSB is the RS for spatial relation, only the serving cell index is configured to the UE. Thus, the UE cannot learn if the SSB configured for spatial relation is CD-SSB or NCD-SSB. |
| Huawei, HiSilicon | Up to R1 | This should be discussed in R1, as in R15.  What RAN2 can discuss is only from signaling design perspective.  RAN2 should not make decision for RAN1. |
| CATT | N | From the view of ‘signaling’, it is not supported now, although adding new NCD-SSB as a new source seems not difficult.  From the view of ‘feasibility’, we do not think this can be determined by RAN2. This issue should be up to RAN1/4. |
| Sharp | Yes | There is no limitation from RAN2. |
| Xiaomi | Yes | Follow majority that leaving it to other WGs. But we think it is better to do so. |
| Spreadtrum | Yes | We don’t find problem for QCL b/w NCD-SSB and CD-SSB. UE can assume the same time-domain position b/w NCD-SSB and CD-SSB, e.g. ssbPositionsInBurst. |

A2.2 Even if it would be feasible, do you think using NCD-SSB as QCL source should be determined by other WGs, e.g., RAN1/4?

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| **Company** | **Yes/No** | **Comments** |
| MediaTek | Yes | This can be left to RAN1 to determine. |
| Nokia, Nokia Shanghai Bell | Yes |  |
| Apple | Yes | RAN4 can add more input. |
| Qualcomm | Yes | RAN2 can at least confirm the feasibility from signaling perspective. Its feasibility in PHY-layer procedures can be studied and decided by RAN1/4. |
| Ericsson | Yes | Those L1 aspects are not in RAN2’s terms of reference. |
| DENSO | Yes | Functional feasibility of NCD-SSB as QCL source is the realm of RAN1/4. As commented to A2.1, RAN2 can feedback the RRC configuration viewpoint. |
| Huawei, HiSilicon | Yes | How it works should be purely up to RAN1/4. |
| CATT | Yes |  |
| Sharp | Yes |  |
| Xiaomi | Yes |  |
| Spreadtrum | Yes | NCD-SSB as QCL source can be determined by other WGs, e.g., RAN1/4.  At least from RAN1’s perspective, QCL source can be related to non-cell defining or cell defining. |

## 2.3 Question 3

**Q3:** [RAN2] whether/when the PCIs indicated by the NCD-SSB and CD-SSB can be the same/different, if both NCD-SSB and CD-SSB are transmitted on the serving cell of RedCap UE

**Summary of papers:**

* [1][2] indicate that there is no limitation on same/different PCI from RAN2 perspective.
* [4][5][6] state that it should be simpler and less potential issues if the same PCI is indicated.

Considering the discussions in the Tdocs submitted and similar views shared by companies; rapporteur suggest the following to be agreed:

1. According to the current RRC specification, PCIs indicated by the NCD-SSB and CD-SSB may be either the same or different if both NCD-SSB and CD-SSB are transmitted on the serving cell of RedCap UE.

A3.1 Do you think PCIs indicated by the NCD-SSB and CD-SSB should be configured as same if both NCD-SSB and CD-SSB are transmitted on the serving cell of RedCap UE, e.g., to avoid disabling ANR? Please elaborate your reply.

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| **Company** | **Yes/No** | **Comments** |
| MediaTek | Yes | The PCIs indicated by the NCD-SSB should be the same as the PCI indicated in the CD-SSB to avoid potential issues. |
| Nokia | Yes | Indicated PCIs should be the same in both NCD-SSB and CD-SSB |
| Apple | Yes | This simplifies things and RAN2 does not need to address all cases that can come out with diff PCI. Why complicate? |
| Qualcomm | Yes | We think it would simplify UE’s operations if the same PCI is used if NCD-SSB is transmitted by the same cell as that of the CD-SSB. That is because different PCIs mean UE's searcher needs to store and use different correlators for PSS/SSS sequences as PCI is carried by PSS and SSS sequences. In addition, since many wideband DL RSs (e.g. DMRS/CSI-RS/TRS are scrambled by PCI, if the RedCap-specific BWP overlaps with the BWP of non-RedCap UE, additional spec efforts are needed to clarify which cell ID needs to be used for the scrambling/descrambling of those DL RSs in the overlapping region |
| Ericsson | Yes | Since NCD-SSBs are meant to be used for connected mode mobility (of RedCap UEs), it is advisable to use the same PCI as for the CD-SSB.  Hence, when introducing new RRC signalling to inform UEs about the NCD-SSB to use in a BWP, it seems unnecessary to provide a PCI explicitly with that new ARFCN. The UE could use the PCI of its serving cell |
| DENSO | No | Even in the current spec, PCI of NCD-SSB can be different from that of CD-SSB. The current ANR reporting can also support to indicate that there is no SIB1 broadcast on the cell to be reported. So, there is no issue even for ANR. |
| Huawei, HiSilicon | See comment | For proposal 1: We think any proposal related to NCD-SSB should be under condition that “only if RAN1 will agree NCD-SSB based measurement.”, or the updated version from Ericsson is fine to clarify this is only the current spec.  OK to use the same PCI. |
| CATT | N/A | There is no need to change the spec and force the same PCI for CD-SSB and NCD-SSB. Otherwise, we need to spend time to evaluate the impact on the non-Redcap UE. |
| Sharp | Yes | The same PCI is better. |
| Xiaomi | Yes | It is simplest that keep the same PCI for CD-SSB and NCD-SSB for one serving cell. (note that in a frequency location, there could be multiple SSBs which has different PCI on behalf of different cells) |
| Spreadtrum | Yes | It is simple for UE to assume the same PCI. |

## 2.4 Question 4

**Q4:** [RAN2/4] whether/when periodicities and/or TX power and/or block indexes (provided by *ssb-PositionsInBurst* in SIB1 or in *ServingCellConfigCommon*) and/or QCL sources of NCD-SSB can be same/different from those of CD-SSB, if both NCD-SSB and CD-SSB are transmitted on the serving cell of RedCap UE

**Summary of papers:**

* [1] mentions that currently periodicities for CD- and NCD-SSB are independent but different periodicity for NCD-SSB may have impact on measurement requirements (RAN4). TX power / block index and QCL are mentioned to be out of RAN2 scope, but in general enhancements to signalling are possible if RAN1/4 consider changes are needed.
* [2] think legacy design can be used and there are no restrictions from RAN2 point of view.
* [4][5][6] think it would be simplest if the properties are shared as much as possible between CD- and NCD-SSB. Generally, it is mentioned that periodicities could be different.
* [6] indicates concern if NCD-SSB is used for idle measurements and cell (re)selection.

Considering the discussions in the Tdocs submitted and similar views shared by companies; rapporteur suggest the following to be agreed:

1. According to the current RRC specification, periodicities and/or TX power and/or block indexes (provided by *ssb-PositionsInBurst* in SIB1 or in *ServingCellConfigCommon*) and/or QCL sources of NCD-SSB may be either the same or different from those of CD-SSB, if both NCD-SSB and CD-SSB are transmitted on the serving cell of RedCap UE.

A4.1 Do you think periodicities and/or TX power and/or block indices (provided by *ssb-PositionsInBurst* in SIB1 or in *ServingCellConfigCommon*) and/or QCL sources of NCD-SSB should be configured same as those of CD-SSB, if both NCD-SSB and CD-SSB are transmitted on the serving cell of RedCap UE?Please elaborate your reply.

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| MediaTek | ?? | There are multiple questions above, so answering them individually   1. Same periodicity as CD-SSB? Not necessary 2. Same TX power? Yes 3. Same block indices? Yes 4. Same QCL source? Yes   It is not really necessary for the NCD-SSB to have the same periodicity as the CD-SSB. On the other hand, it is important that the NCD-SSB has an appropriate periodicity for the function(s) that it serves. For example, if the NCD-SSB is meant to be used for tracking (i.e. TRS is absent) then it needs to be transmitted frequently (≤ 20ms). On the other hand, if the NCD-SSB is meant to be used for RRM purposes, it can be transmitted less frequently (e.g. 80ms) |
| Apple | Pls see comments | Tx power and SSB burst set config/indices and QCL should be the same. Better to have same periodicities as well. |
| Qualcomm | See comments | If NCD-SSB is to be used for measurements, then it is important for it to have the same power level (and hence the same SCS) as that of CD-SSB. If their Tx power levels can’t be the same, then network should at least signal the difference between their power levels to UE.  If NCD-SSB is used as QCL source, then it should have the same block indices as those of the CD-SSB.  The periodicity of NCD-SSB and CD-SSB could be different, as long as the periodicity of NCD-SSB is not too sparser than that of the CD-SSB (otherwise, UE may still need to retune to measure CD-SSB). And we do not see any need to configure NCD-SSB with a periodicity shorter than that of CD-SSB. To ensure these requirements, we think a simple rule can be that periodicity of NCD-SSB = max(20ms, periodicity of CD-SSB). Basically, they should have the same periodicity but there is no need to configure a periodicity shorter than 20ms for NCD-SSB, to avoid unnecessary overheads. |
| Ericsson |  | This should at least be the starting point.  Hence, when introducing new RRC signaling to inform UEs about the NCD-SSB to use in a BWP, it seems unnecessary to provide a ssb-PositionsInBurst or TX block power with that new ARFCN. The UE should use the corresponding parameters provided for its serving cell.  If there is a need to configure those properties differently, the impact should be investigated carefully. If considered feasible, it is of course possible to convey the required parameters in ASN.1. |
| DENSO | Yes | Although there is not such a restriction on NCD-SSB in the current spec, it is simpler and so desirable to share the same properties between CD-SSB and NCD-SSB. |
| Huawei, HiSilicon | No | The periodicity of NCD-SSB should be larger than/never less than that of CD-SSB. Otherwise, gNB has to transmitt both CD-SSB and NCD-SSB in the time, which cause lots of resource occuptaion for NW. |
| CATT |  | That depends:  If NCD-SSB is NOT aiming at replacing CD-SSB, i.e. used for neighbor cell measurement as legacy, there is no need to force the same configuration in any of periodicities/TX power/block indices.  If NCD-SSB is aiming at replacing CD-SSB, to avoid duplicated situation (e.g. both NCD-SSB and CD-SSB are mapped to shared RO), same configuration may be suitable. However, as commented in A.1 and A.2, this needs quite a lot effort and spec change. |
| Sharp |  | The same configuration is better. But it is also possible to configure different configuration if needed. |
| Xiaomi |  | Same view as MTK. |
| Spreadtrum | Yes | Configuring the same values is simple for UE implementation and specification (shared IEs, e.g. ssb-PositionInBurst).  For the concerns for using NCD-SSB for idle mode, with Option 2, if gNB does not configured paging CSS in the separate initial DL BWP, there is not NCD-SSB to be transmitted for idle mode.  For SSB periodicity, from measurement perspective, if NCD-SSB is mainly used for connected mode, the NDC-SSB periodicity is up to gNB configuration to meet the requirement. |

## 2.5 Question 5

**Q5:** [RAN2/4] whether it is necessary to introduce configuration limitations for NCD-SSB (e.g., regarding frequency locations, periodicity), e.g., to ensure coexistence with legacy UEs

**Summary of papers:**

* In general, it is understood there is currently no limitation in specifications.
* [1] mention more discussion is needed in RAN2 whether there should be limitations.
* [2] mention RAN4 should discuss frequency location.
* [4][6] say sync raster should be preferably avoided.
* [5] says no limitation is needed assuming there are only RedCap UEs within RedCap-specific BWPs.

A5.1 Do you think configuration limitations for NCD-SSB (e.g., regarding frequency locations, periodicity) should be introduced?Please elaborate your reply.

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| **Company** | **Yes/No** | **Comments** |
| MediaTek | Yes | Sync raster: The NCD-SSB should avoid the sync raster to prevent it being detected as a CD-SSB during cell search in initial cell selection.  Periodicity: If NCD-SSB is meant to be used for synchronization/tracking, the periodicity should be ≤ 20ms. If NCD-SSB is not meant to be used for sync purposes (i.e. TRS is configured), then there are no limitations on its periodicity. |
| Apple | Yes | Same view as MediaTek |
| Qualcomm | Yes | Since we do not want NCD-SSB to interfere with legacy UEs’ cell search, it is better to have NCD-SSB configured off sync raster.  To avoid error when NCD-SSB is discovered by legacy UEs, NCD-SSB should have the same subcarrier spacing, PCI (hence PSS/SSS) and ssb-PositionsInBurst as the CD-SSB of UE’s serving cell. |
| Ericsson | No | When introducing new RRC signaling to inform UEs about the NCD-SSB to use in a BWP, this information will be provided as the SSB’s ARFCN. I.e., the new RRC signaling will allow configuring NCD-SSBs on the sync raster and off the sync raster.  While it may often be beneficial to configure NCD-SSB **off** the sync raster, there may be cases where an SSB ARFCN on the sync raster is preferable. Since supporting ARFCNs **on** the sync raster does not need additional signaling, we see no need to restrict the configuration in the specification. |
| DENSO | Up to RAN1/4 | We agree that there is no limitation currently since Rel-15, e.g. for NSA only cells. However, it should be decided by RAN1/4, as the raised restriction is relevant to their specs. |
| Huawei, HiSilicon | Yes | The periodicity of NCD-SSB should be larger than that of CD-SSB. |
| CATT | see comment | Regarding to the co-existence and specifically to sync raster issue, this cannot be determined by RAN2 but should be up to RAN4. |
| Sharp | See comments | Not sure whether they can be decided by RAN2. Maybe they can be decided by RAN4. |
| Xiaomi | Yes | NCD-SSB should be configured off sync raster. Otherwise legacy UE would search unnecessary SSB. |
| Spreadtrum | Maybe Yes | NCD-SSB may be placed off the sync raster to avoid being detected in cell search. |

## 2.6 Question 6

**Q6:** [RAN2/4] if CD-SSB is not transmitted in the non-initial DL BWP of RedCap UE, whether it is feasible to transmit periodic CSI-RS for UE to use as an alternative of SSB in the non-initial BWP of RedCap UE or rely on UE performing RF retuning as in measurement gap outside active BWP for BWP without SSB nor CORESET#0 operation.

**Summary of papers:**

* In brief, [1][6] bring up that support and procedures for CSI-RS or retuning for SSB already exist in RAN2 specifications.
* [2][4] bring up issues with retuning and negative impact on UE power consumption. [4] mentions additional UE complexity and that CSI-RS is not widely used in the field. Measurement gaps are mentioned to have negative impact on system performance.
* [5] mentions CSI-RS does not provide the same level of information (e.g. timing/tracking). Retuning is feasible if NCD-SSB periodicity is large and UE needs to correct e.g. tracking.

A6.1 Do you agree that use of CSI-RS for cell and beam RLM and measurements is already supported from RAN2 signalling standpoint? i.e., it is feasible to transmit periodic CSI-RS for a UE to use as an alternative of SSB in the non-initial BWP of RedCap UE?

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| MediaTek | Yes, but | CSI-RS is an optional feature, and it cannot be depended upon as the only solution when the UE operates on a DL BWP that does not include the CD-SSB.  In addition, use of measurement gaps for these procedures are also undesirable. There’s the obvious drawback of scheduling interruptions. In addition, as the gap is shared with inter-freq and inter-RAT measurements, there will be an overall delay to intra frequency measurements which degrades mobility performance.  [Huawei]: we note the R1 LS is asking about the current situation on whether the spec support to use CSI-RS, rather than asking whether this is mandatory supported by UE or UE performance. |
| Apple | Not fully supported. We think it’s better to use NCD-SSB than rely on CSI-RS | Share views with Mediatek |
| Qualcomm | No | From purely signaling point of view, CSI-RS is supported for use in measurement procedures such as RRM, RLM, BFD, etc. However, as we argued in our paper [4], CSI-RS is an optional UE capability, and it typically is not widely available in the field. And its use requires extra complexity in UE implementation. Hence the use of CSI-RS should not be considered as the baseline for those measurement procedures.  [Huawei]: The question from R1 is asking for feasibility, rather than asking whether all UEs support this and the complexity. |
| Ericsson | Yes | CSI-RS for RRM measurements, RLM, and beam failure detection are supported from signaling perspective. In some cases, using CSI-RS for RLM and beam failure detection is the default behavior. |
| DENSO | Yes | At least, from RAN2 specification viewpoints. |
| Huawei, HiSilicon | Yes | There should be no doubt on the current specification. |
| CATT | Yes | It is clear that CSI-RS for RRM, RLM, BFD are already supported from signaling perspective. |
| Sharp | See comments | CSI-RS is supported in current RAN2 specs. But for whether as an alternative of SSB in the non-initial BWP of RedCap UE, we agree with MediaTek. |
| Xiaomi | Yes | Regarding feasible, we would say yes. |
| Spreadtrum | Partially Yes | CSI-RS can be used for cell/beam RLM and measurement, but it is optional capability. It can be an optional capability for RedCap UE as well, but cannot replace NCD-SSB.  Agree vivo’s viewpoint in contribution that timing of CSI-RS is still based on SSB, so using CSI-RS will still cause the RF retuning for timing acquisition. |

A6.2 Do you think RAN2 should use this as an alternative? Please elaborate your reply.

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| MediaTek | No | This is not a viable alternative. CSI-RS based RRM is an optional feature that adds extra complexity to the UE - we’re actively trying to avoid additional complexities in this WI for RedCap. |
| Apple | No |  |
| Qualcomm | No | See our reply to Question A6.1 |
| Ericsson |  | Since the necessary signaling and procedures exist, we see no reason why RAN2 could discourage the use of CSI-RS for the above-mentioned purposes.  Note: It is not up to RAN2 to decide whether the use of CSI-RS (possibly in combination with re-tuning to the CD-SSB) is feasible from RAN1/4 perspective. |
| DENSO |  | Question 6 should be answered by RAN4, as it is more relevant to their specification |
| Huawei, HiSilicon | Yes | This alternative can always be used, since it is already supported from specification. If some UE does not support CRI-RS based measurement, it would be RAN1 discussion.  Anyway, RAN2 see the feasibility to use this alternative.  The question is asking whether RAN2 see the show-stopper to use this as alternative. If there is no agreement to forbidden this, it can always be used by the UE supporting this feature. |
| CATT | Yes | From RAN2’s point of view, we do not see why this cannot be an alternative. CSI-RS is a mature technique and exists since LTE. |
| Sharp | No |  |
| Xiaomi | No | We don’t think CSI-RS for idle/inactive is already mature. And compared introducing NCD-SSB, we don’t see too much gain. Furthermore, even without NCD-SSB in redcap dedicated BWP, UE still can use legacy mechanism (i.e. retune). |
| Spreadtrum | No | CSI-RS based solution should be still optional for UE capability. |

## 2.7 Question 7

**Q7:** [RAN2/4] whether it is feasible for a RedCap UE to retune to a CD-SSB rather than use an NCD-SSB of larger periodicity

**Summary of papers:**

* [1][6] think this is feasible and already supported by specifications.
* [2] think NCD-SSB periodicity should meet requirements for UE to perform required functionalities (i.e. no retuning should be required).
* [4] think this is possible but requires measurement gaps for BWPs without SSB. Thus, this is not desirable. It is also mentioned NCD-SSB does not require much overhead thus their use is justified.
* [5] mentions retuning is feasible if NCD-SSB periodicity is large and UE needs to correct e.g. tracking.

A7.1 Do you think it is feasible for a RedCap UE to retune to a CD-SSB rather than use an NCD-SSB of larger periodicity? Please elaborate your reply.

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| MediaTek | Yes, but | While it is feasible to retune to a CD-SSB, it comes at the cost of frequent measurement gaps if needed for tracking. Furthermore, these gaps will be required by all RedCap UEs operating in that BWP. The result is that none of these UEs can be scheduled during these gaps. The overhead of signaling an NCD-SSB is surely minor compared to the inability to schedule any UE for the duration of a gap! |
| Nokia, Nokia Shanghai Bell | Yes | RedCap UE can retune to a CD-SSB for measurements. This would be simple from RAN2 specification point of view. |
| Apple | Yes | In IDLE/INACTIVE yes, but in CONNECTED mode, unnecessary gaps are needed, which is what we are trying to avoid. |
| Qualcomm | No | Retuning may be feasible in theory. But in our view, it is not a desirable solution for both RedCap UE and NW, because retuning requires intra-frequency measurement gaps. Due to reduced capabilities of RedCap UEs, such measurement gaps reduce UE’s throughput, increase UE’s power consumption and cause load imbalance and loss in spectral efficiency for network.  In our paper [4], we have shown that NCD-SSB does NOT consume much overhead (e.g. ~1% or lower in typical configurations). So its use is well justified by the benefits it can enable for RedCap UEs. |
| Ericsson | Yes | … from signaling perspective: UEs may re-tune to the CD-SSB during DRX and during intra-frequency gaps. The necessary procedures and signaling exists in the current versions of the specifications.  Whether this is feasible alone or in combination with CSI-RS should be determined by RAN1/4. |
| DENSO | Yes | Same understanding that it is already supported functional-wise. |
| Huawei, HiSilicon | Yes | This is feasible and already supported by specifications.  For the comments from QC and MTK, we understnad the R1 question is only asking about “feasiblity“, rather than whether it is desireable. Whether to alwasy use it considering the pros and cons will be decided by R1. |
| CATT | Yes | When NCD-SSB periodicity is too large, retuning to a CD-SSB is more suitable if the UE is desire to read SSB as soon as possible. |
| Sharp | Yes | It is feasible and the final decision depends on RAN4. |
| Xiaomi | Yes | Same view as MTK. |
| Spreadtrum | No | For idle/inactive mode, if paging CSS is configured, NCD-SSB is necessary as Option 2. The power saving for paging is important, so the NCD-SSB should conduct each UE group for PEI/PO reception and serving cell measurement. The periodicity of NCD-SSB should be not too sparse for UE power saving. The measurement gap is another critical problem.  For connected mode, NCD-SSB is used for measurement and RLM. RF retuning will cause power consumption.  Therefore, NCD-SSB should be dense enough. |

## 2.8 Question 8

**Q8:** [RAN2/4] any other potential impacts identified by RAN2/4 on support NCD-SSB for measurement

**Summary of papers (for Q8 and general proposals):**

* [1] mentions large impact from serving cell and neighboring cell measurements using NCD-SSB. RLM/BFD/link recovery require specification enhancement. Possible different properties/configuration of NCD-SSB and CD-SSB require more evaluation to understand full impact. It is also mentioned that RAN2 should evaluate the work load. [1] thinks the work is not practical to complete in Rel-17.
* [2] think high level RAN2 principle would be to avoid frequent RF retuning to save UE power.
* [4] proposes that NCD-SSB can be used in place of CD-SSB if it is off the sync raster, has same PCI, SCS, Tx power level, *ssb-PositionInBurst,* and is fully QCL’s with CD-SSB. [3] includes corresponding draft LS replies.
* [5] thinks it is feasible to adapt NCD-SSB and think impact in RAN2 should be minimal if same configuration is used between CD- and NCD-SSB (periodicity can be larger in idle/inactive).
* [6] thinks idle mode measurements and paging receptions should be done on BWP with CD-SSB and CORESET#0. If NCD-SSB are introduced, they should not be used for idle mode measurements and mobility. NCD-SSB should have similar properties as CD-SSB.

A8.1 Are there any other potential impacts regarding supporting NCD-SSB for measurements? Please elaborate your reply.

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| **Company** | **Yes/No** | **Comments** |
| DENSO | Yes | If RedCap UE is configured with the separate initial DL BWP wherein CD-SSB, CORESET#0 and SIBs are not present, it is not clear how such a DL BWP can be configured by the existing BWP configuration option 1/2 described in Annex B.2 of 38.331. |
| Huawei, HiSilicon |  | The above/below whole list of potential impacts should be provided to RAN1.  Whether one proposed potential impact will really impact the spec should be discussed after RAN1 make the final decision.  We should give RAN1 the correct impression that the discussion in RAN2 require more efforts. |
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# 3 Conclusion

TBD

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