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**
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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** |
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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** |
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## 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] mentions QCL discussion is not in RAN2 scope whereas [6] mentions that it is currently not supported and using NCD-SSB as QCL source should be determined 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** |
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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** |
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## 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. PCIs indicated by the NCD-SSB and CD-SSB can be either 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** |
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## 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. 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 either 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** |
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## 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** |
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## 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.

*HW: Non RC supports CSI-RS based RRM/RLM meas (capa). SSB based meas with gap when active BWP doesn’t cover SSB. Is feasible and already supported or UE can rely on retuning.*

*vivo:SSB should be anyways associated with the CSI-RS transmission, requires re-tuning which impacts UE performance. Not feasible due to timing requirement. From procedure pov it is feasible to do re-tuning but this is different approach than legacy design. No feasible as will increase UE power consumption.*

*QC: requires extra complexity, not widely configured in the field. SSB less overhead. CSI-RS need not be excluded even if SSB used. => Reply RAN2 thinks should not be used as alternative. Meas gap no desirable either.*

*Apple: CSI-RS can provide timing info but may require spec changes for RO handling and meas gaps results in system inefficiencies. CSI-RS does not provide same level of information.*

*Eri: Supported already from RAN2 perspective, RRC signaling to use a share of gaps for intra-freq exists (up to RAN4 if feasible)*

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

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| **Company** | **Yes/No** | **Comments** |
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## 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** |
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## 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** |
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# 3 Conclusion

TBD

# References

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, RAN2#116e, November 2021

1. [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, RAN2#116e, November 2021

1. [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, RAN2#116e, November 2021

1. [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, RAN2#116e, November 2021

1. [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, RAN2#116e, November 2021

1. [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, RAN2#116e, November 2021