3GPP TSG-RAN WG1 Meeting #109-e R1-22xxxxx

e-Meeting, 9th – 20th May 2022

**Agenda Item: 8.6.1**

**Title: FL summary for incoming LS (R1-2203046) on introduction of an offset to transmit CD-SSB and NCD-SSB at different times**

**Source: Moderator (Ericsson)**

**Document for: Discussion, Decision**

# 1 Introduction

This feature lead (FL) summary (FLS) concerns the Rel-17 work item (WI) for support of reduced capability (RedCap) NR devices [1]. Earlier RAN1 agreements for this WI are summarized in [2], which also includes links to earlier FLSs. The latest Rel-17 NR higher-layer parameter list sent from RAN1 to RAN2 can be found in [3].

This document captures the following email discussion for the incoming LS [4] and related contributions [5] – [14]:

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| [109-e-R17\_RedCap-02] Email discussion on incoming LS ([R1-2203046](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_109-e/Docs/R1-2203046.zip)) on introduction of an offset to transmit CD-SSB and NCD-SSB at different times by May 12 – Johan (Ericsson)   * Relevant tdocs: R1-2203120, R1-2203495, R1-2203590, R1-2204271, R1-2204434, R1-2203053, R1-2203109, R1-2203517, R1-2204711, and R1-2204771 |

The issues in this document are tagged and color coded with High Priority or Medium Priority. The issues that are in the focus of this round of the discussion are furthermore tagged FL2.

**FL1 Question 1-1a: Please consider entering contact info below for the points of contact for this email discussion.**

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| --- | --- | --- |
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| Qualcomm | Jing Lei | leijing@qti.qualcomm.com |
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| LGE | Jay KIM | jaehyung.kim@lge.com |

# 2 Discussion

RAN1 and RAN4 have received an LS [4] from RAN2 with the following content:

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| **1. Overall Description:**  In RAN2#117-e, it was concluded that, from RAN2 signalling standpoint, CD-SSB and NCD-SSB(s) may be transmitted at different times by configuring an offset. RAN2 would like to ask RAN4 and RAN1 whether such offset is feasible/needed.  **2. Actions:**  **To RAN4 and RAN1**  **ACTION:** RAN2 kindly asks RAN4 and RAN1 to take the information above into consideration and provide feedback. |

Contributions [5] – [14] express views on the topic raised in the LS. This topic has also been brought up in the previous RAN1 meeting in contribution [15] and discussed on pages 94-106 in the FLS in [16], where the discussion ended with an FL note that “RAN1 can come back to these topics if necessary once they have been treated in RAN2”.

Regarding the ***necessity*** of a configurable time offset between CD-SSB and NCD-SSB, some contributions [11, 12, 14] express that it is beneficial or even needed to have the possibility to transmit CD-SSB and NCD-SSB at different times to avoid power shortage at the gNB side, especially if/when power boosting is used for SSB the transmission.

Contribution [5] expresses that there is no strong need for a time offset and that in many cases it will be desired to have zero offset to minimize the ON time for power saving purposes, but that it would be OK if it is up to the gNB whether to configure a time offset and the UE cannot expect a time offset.

Contribution [7] expresses that there is no need for a time offset and points out that CD-SSB and NCD-SSB are configured without offset in legacy.

**FL1 High Priority Question 2-1a: Is a configurable time offset between CD-SSB and NCD-SSB *needed*? Please elaborate on your answer in the Comments field.**

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| **Company** | **Y/N** | **Comments** |
| Nordic | N | Assuming e.g. 60Mhz channel BW and 162RB of 30kHz SCS there  1 SSB can be boosted 8x while 2SSB only 4x. In our opinion boosting SSB 6dB is enough, or at least benefit to bootst 3dB more is not really clear to us.  Therefore we think offset is not essential. |
| Qualcomm | N | In NR R15/16, a CD-SSB can be FDMed with other DL channels/signals with power boosting on the same set of symbols. Therefore, we don’t think it is necessary to configure such a time offset between CD-SSB and NCD-SSB.  On the other hand, such time offset can only be configured with half-frame granularity, which does not provide much flexibility for scheduler but incurs DL resource fragmentation for legacy UEs. |
| Nokia, NSB | N | We don’t think time offset is necessary. First, SSB coverage is robust compared to other DL channels and generally power boosting is not necessary. Even if power boosting is used, it is our view that there is sufficient power for sharing between CD-SSB and NCD-SSB. Second, introducing an offset increases implementation complexity and introduces further scheduling restrictions due to e.g. QCL relationship between CD-SSB and NCD-SSB, resource fragmentation, different collision handling between BWPs, etc. |
| CATT |  | The question ‘*needed’* is a little ambiguous. In our view, without time offset the system may still work (although maybe reluctantly). But a configurable time offset is more flexible and can ease the deployment of NCD-SSB. |
| Samsung | N | We don’t think this is necessary.  Introducing offset may increase RO validation, semi-DL determination issues. This will also increase the implementation effort for both UE and gNB. |
| Huawei, HiSilicon | Y | It is very necessary to enable NCD-SSB(s) and CD-SSBs transmitted at different time, by network configurations. Because in current commercial network, to guarantee the coverage of SSB, the network will likely perform power boosting for SSB with up to even higher level than what one may consider. Considering only CD-SSB have been deployed in most networks, the impact on gNB implementation can be accepted. However, now multiple NCD-SSBs can be transmitted additionally since R17. If the SSBs are transmitted at same time, the network has to perform power boosting for multiple SSBs simultaneously. On one hand, it may bring great challenge to gNB implementation. On the other hand, the power of the other channels may be reduced, which means that the performance of these channels will suffer performance loss. Thus, it is not practical to ALWAYS require gNB to always transmit CD-SSB and NCD-SSB(s) at same time instance. To solve the above issue, NCD-SSB(s) should be allowed to be transmitted at different time instances.  There is no such BWP collisions or compelxibity issue – from single UE perspective it is same as CD-SSB in terms of rate matching, RO collision/validation. |
| MediaTek |  | After hearing companies’ views, we are becoming less and less convinced that a configurable time offset is indeed needed. But we are open for discussion. What we really concern is the related technical details (i.e. feasibility) should be well taken care of and clarified which may be complicated and time consuming. |
| ZTE, Sanechips | N | gNB still have the ability to let UE camp on the CD-SSB and configure less NCD-SSB to make sure that the impacts on gNB is acceptable. |
| DOCOMO | N | We don’t think the time offset is necessary. We agree that the time domain configuration (e.g., periodicity) of NCD-SSB can be configured independently from that of CD-SSB, and NCD-SSB and CD-SSB may not be always transmitted at the same time by gNB, however, we don’t see any issue on simultaneous transmission of NCD-SSB and CD-SSB. |
| CMCC |  | A time offset between CD-SSB and NCD-SSB is not neccessary but configurable by gNB. If gNB concerns about power boosting, it has the flexibility to configure an offset. |
| FUTUREWEI |  | We understand the point about power boosting. If NCD-SSB and CD-SSB are located on the same symbols and if they are boosted, the remaining REs will have decreased power, which impacts the performance of the channels using those REs. In addition, power boosting over non-adjacent RBs may lead to unwanted 3rd order modulation products (in RF). Thus, having a time offset can mitigate these two issues. |
| Intel |  | Same view as CATT – it is not strictly necessary, but can provide flexibility to the gNB. |
| NEC | N | It would not be needed for the purpose of power boosting of SSB, as in our understanding, SSB is not bottle-neck of DL coverage. It would not be essential in CR phase. |
| Ericsson | Not *needed* | Although we do not see a strong need for such an offset, we are fine with introducing the offset as long as a zero offset can be configured. |
| LGE | N | It may be useful in some cases, but we don’t think it is needed. |
| FL2 | Most received responses indicate that a configurable time offset between CD-SSB and NCD-SSB is not needed. One response expresses that a time offset is needed to allow for enough power boosting to ensure the desired coverage. Two responses indicate that SSB coverage is robust compared to other channels and that it is therefore not a bottleneck for coverage and thus power boosting is generally not necessary. Three responses express that there is enough margin to do power boosting of both CD-SSB and NCD-SSB without a time offset if this would be needed.  **High Priority Question 2-1b: Companies are invited to comment further on:**   1. **Whether there is a need for SSB power boosting** 2. **Whether there is enough margin to do the necessary power boosting for both CD-SSB and NCD-SSB without a time offset between the two** | |
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Regarding the ***feasibility*** of a configurable time offset between CD-SSB and NCD-SSB, several contributions [6, 8, 11, 12, 14] express that it is feasible.

The following issues (concerns or other aspects to consider) are brought up in the contributions [5, 7, 9, 12, 13]:

1. Impacts on mapping pattern for SSB in slots within a half-frame [5]
2. Impacts on the QCL relationship [7]
3. RAN1 specification impacts on SSB starting symbols [7]
4. No support for offset resulting in collision between CD-SSB and NCD-SSB with different TCI states [9]
5. Collision handling between SSB and UL transmissions for HD-FDD [12]
6. Available slot determination for PUCCH/PUSCH repetitions for HD-FDD [12]
7. RACH occasion validation and SSB-RO association [13]
8. PDSCH rate matching around SSB [13]

**FL1 High Priority Question 2-2a: Is a configurable time offset between CD-SSB and NCD-SSB *feasible*? Please elaborate on the issues listed above in the Comments field.**

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| **Company** | **Y/N** | **Comments** |
| Nordic | Y |  |
| Qualcomm |  | To solve the issues listed above, such time offset can only be configured with half-frame granularity by RRC. The half-frame granularity does not provide much flexibility for the scheduling of NCD-SSB, but incurs additional issues for NW and UE, such as:   1. DL resource fragmentation 2. complicating the rate matching/collision handling procedures 3. imposing additional constraints on the configuration of TDD slot format 4. potential degradation of UL throughput in TDD |
| vivo | Y | It is feasible to configure time offset of NCD-SSB relative to CD-SSB, and the offset is half-frame level. |
| Nokia, NSB | Y | While we think it’s feasible to configure a time offset, our preference is not to support time offset. |
| CATT | Y | We do not see serious issues if (1) Time offset is in half-frame level (2) RedCap UE is required to deal with only one SSB (either CD- or NCD- one) within the active BWP. |
| Samsung | Y | We think it is feasible, but may increase a lot of uncessary effort.  Agree with vivo and Qc that, such time offset can only be configured with half-frame granularity by RRC. |
| Huawei, HiSilicon | Y | The SSB pattern within half-frame can be kept same with R15/16, NCD-SSBs and CD-SSBs can locate at different half-frames within same SF or different SFs, it can be up to network implementation. It won’t impact pattern for SSB nor QCL relationship.  Repley to Qualcomm’s concern:   1. There won’t be DL resource fragmentation issue, because discontinuous frequeney resource allocation is mandatorily supported for all UEs. 2. Rate matching/collision handling for (N)CD-SSB is already supported in Rel-15/16, it will cause any additional complexity. 3. The configurations of TDD slot format and NCD-SSB can be up to network implementation, network will tradeoff between these two issue, from network’s perspective, it is not a problem. 4. Same as Q3, it can be up to network implementation. |
| MediaTek |  | Before deciding the feasibility of NCD-SSB, we first should at least discuss whether NCD-SSB should be taken into consideration for determining valid RACH occasion in TDD as described in Clause 8.1 of TS38.213.  Let’s assume an UL BWP is configured with RACH occasions which physically are shared between legacy UEs and RedCap UEs (from the network perspective). Its paired DL BWP for legacy UEs contains CD-SSB while its paired DL BWP for RedCap UEs contains NCD-SSB. Note NCD-SSB is configured to RedCap UEs via dedicated signalling. Should RedCap UEs take NCD-SSB into consideration and ruling out (i.e. invalidating) RACH occasions that collide with NCD-SSBs or are within Ngap symbols of NCD-SSBs? (See 38.213 for detailed rules.)  If NCD-SSB is not considered, it is not aligned with the original design principle in R15 that PRACH transmission should not interfere SSB reception.  On the other hand, if NCD-SSB is considered, to our understanding, legacy UEs always take SSBs in account for valid RO determination. As legacy UEs are not configured with NCD-SSB and hence only CD-SSBs have been considered. In this case, if there is a non-zero time offset between CD-SSB and NCD-SSB, it may wind up with different mappings between SSBs and valid ROs for legacy UEs and RedCap UEs.  Some discussions and agreements are needed at least for this aspect before making agreements to support for configurable time offsets. |
| ZTE, Sanechips | Y | It is feasible but would bring out massive discussions. For example, the offset value should be determined, and QCL relationship should be discussed. |
| DOCOMO | Y | We think the time offset between CD-SSB and NCD-SSB is feasible and should be the half-frame level if configured. |
| CMCC | Y | It is feasible and up to gNB to configure time offset of NCD-SSB. |
| FUTUREWEI | Y |  |
| Intel | Y | We think it’s feasible to configure non-zero offsets between CD- and NCD-SSB, and all of the raised concerns can be avoided by proper choice of the offset value or are natural consequences of such a configuration, should the gNB choose to configure such.  However, if we are risking opening new long discussions in RAN1 on how to configure the offsets reasonably, then we’d prefer not to pursue such a track, instead assume zero-offset case only, and respond to RAN2 accordingly. |
| NEC |  | It is not clear for us what the offset is. Multiple companies assume it half-frame level. Half-frame level offset would be feasible, though in case periodicity of CD- and NCD-SSB are different, offset between CD- and NCD-SSB would vary. |
| Ericsson | Y | We think the time offset could be feasible.  However, some time offset values would have more impact than the other. Currently, different SSB indexes have fixed (for a particular SCS) time-domain locations in the slots within a half-frame. Therefore, if the offset value is, for e.g., less than a half-fame, the transmission of NCD-SSB and CD-SSB may still occur at the same time (but with different indexes). Assuming a half-frame granularity of the time offset could help to avoid concurrent transmission of NCD-SSB and CD-SSB (which is the main motivation for introducing the offset) and minimize the impact on SSB mapping pattern. |
| LGE | Y | Even if we are not in favor of configuring the time offset, we don’t think there is a feasibility issue here. |
| FL2 | Most received responses indicate that a configurable time offset between CD-SSB and NCD-SSB is feasible, at least if the time offset has half-frame granularity. Three responses (from Qualcomm, MediaTek, and NEC) do not reply yes or no and express concerns with the feasibility.  **High Priority Question 2-2b: Companies are invited to comment on the concerns expressed in the responses above from Qualcomm, MediaTek, and NEC.** | |
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Regarding the ***impacts*** on RAN1 specifications and the RRC parameter list [3] from a configurable time offset between CD-SSB and NCD-SSB, the submitted contributions do not contain any detailed text proposals. Companies are invited to describe the expected impacts in detail, were such a configurable time offset to be introduced.

**FL1 High Priority Question 2-3a: If a configurable time offset between CD-SSB and NCD-SSB is introduced, what are the *impacts* on the RAN1 specifications and the RRC parameter list [3]? Please be as detailed as possible.**

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| **Company** | **Comments** |
| Nordic | With assumption that there is only one SSB within UEs BWP, NCD or CD, the spec should just work fine, given that UE assumes that only SSB within BWP matters, for collisions for RO handling, etc. But of course, having offset between CD and NCD would mean that UE must treat collisions differently depending on BWP, which is clearly not desirable. |
| Qualcomm | Please see our comments on Question 2-2a. |
| Samsung | Agree with Qc on   1. complicating the rate matching/collision handling procedures 2. imposing additional constraints on the configuration of TDD slot format   we need to clarify UE behavior on how to deterimate slot format, and whether some of the configuration is error case or not, and further clarify HD-FDD |
| Huawei, HiSilicon | From RRC perspective, an offset between CD-SSB and NCD-SSB is needed per NCD-SSB, to be signaled to UE. RAN1 specification does not seem to require changes. |
| ZTE, Sanechips | 1. The offset value should be determined 2. The UE behavior for NCD-SSB detection also should be determined. 3. Impacts on QCL relationship should be discussed. |
| DOCOMO | As pointed out by companies, at least the rate matching and collision handling needs to be clarified further. |
| CMCC | Candidate values of offset need to be determined. |
| Intel | Mainly in terms of signalling of the offset itself, and collision handling between DL/UL link directions. However, for rate-matching and DL-UL conflicts, NCD-SSB needs to be captured in specs in addition to CD-SSB. Thus, *spec impact* may be limited (we do not deny there would be different impact to operations for the gNB and UE though). |
| Ericsson | Regarding RAN1 specification impacts, we tend to agree with Nordic. Please also see our response to Q2-2a.  Regarding RRC parameter list impacts, there would be impacts due to introduction of a new RRC parameter and due to introduction of new candidate values for the time offset (which may require further discussions in RAN1/RAN2). |
| FL2 | The following potential impacts are brought up in the received responses:   1. New RRC parameter(s) 2. Candidate offset value(s) 3. SSB starting symbols and mapping pattern 4. UE behavior for rate matching 5. UE behavior for collision handling (including HD-FDD cases) 6. UE behavior for determination of TDD slot format 7. UE behavior for NCD-SSB detection 8. QCL relationship 9. RO validation   It can be expected that the potential impacts #1 and #2 listed above will have impacts on the RRC parameter list. Companies are invited to comment on which ones of the potential impacts #3 through #9 that will have impacts on RAN1 specifications if the proposed configurable time offset is introduced.  **High Priority Question 2-3b: Which ones of the potential impacts #3 through #9 listed above will have impacts on the RAN1 specifications if the proposed configurable time offset is introduced?** |
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# References

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| --- | --- | --- | --- |
| [1] | [RP-220966](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_95e/Docs/RP-220966.zip) | Revised WID on support of reduced capability NR devices | Ericsson |
| [2] | [R1-2202535](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_108-e/Docs/R1-2202535.zip) | RAN1 agreements for Rel-17 NR RedCap | Rapporteur (Ericsson) |
| [3] | [R1-2202759](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2202759.zip) | Consolidated higher layers parameter list for Rel-17 NR | Moderator (Ericsson) |
| [4] | [R1-2203046](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203046.zip) | LS on introduction of an offset to transmit CD-SSB and NCD-SSB at different times | RAN2, Ericsson |
| [5] | [R1-2203120](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203120.zip) | On introduction of an offset to transmit CD-SSB and NCD-SSB at different times | Ericsson |
| [6] | [R1-2203495](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203495.zip) | Draft Reply LS on introduction of an offset to transmit CD-SSB and NCD-SSB at different times | Vivo |
| [7] | [R1-2203590](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203590.zip) | Discussion on NCD-SSB offset | ZTE, Sanechips |
| [8] | [R1-2204271](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204271.zip) | Discussion on RAN2 LS on introduction of an offset to transmit CD-SSB and NCD-SSB at different times | CMCC |
| [9] | [R1-2204434](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204434.zip) | Discussion on LS on introduction of an offset to transmit CD-SSB and NCD-SSB at different times | NEC |
| [10] | [R1-2203053](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203053.zip) | Remaining aspects of Bandwidth Reduction for RedCap UEs | Futurewei |
| [11] | [R1-2203109](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203109.zip) | Remaining issues on UE complexity reduction | Huawei, HiSilicon |
| [12] | [R1-2203517](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203517.zip) | Remaining issues on reduced maximum UE bandwidth | Vivo, Guangdong Genius |
| [13] | [R1-2204711](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204711.zip) | On RedCap UE complexity reduction | MediaTek Inc. |
| [14] | [R1-2204771](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204771.zip) | Remaining details on UE complexity reduction for Rel-17 RedCap | Intel Corporation |
| [15] | [R1-2200918](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2200918.zip) | On RAN1 aspects of RAN2 led issues for RedCap | Huawei, HiSilicon |
| [16] | [R1-2202532](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_108-e/Docs/R1-2202532.zip) | FL summary #5 on reduced maximum UE bandwidth for RedCap | Moderator (Ericsson) |