

**Agenda item:** 9.5.1  
**Source:** Sharp  
**Title:** Discussion on remaining details of on-demand SSB operation on SCell  
**Document for:** Discussion

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## 1 Introduction

The Rel-19 WID on enhancements to NES for NR was approved in [1], which includes the following objective:

1. Specify procedures and signaling method(s) to support on-demand SSB SCell operation for UEs in connected mode configured with CA, for both intra-/inter-band CA. [RAN1/2/3/4]
  - Specify triggering method(s) (select from UE uplink wake-up-signal using an existing signal/channel, cell on/off indication via backhaul, SCell activation/deactivation signaling)
  - Note1: On-demand SSB transmission can be used by UE for at least SCell time/frequency synchronization, L1/L3 measurements and SCell activation, and is supported for FR1 and FR2 in non-shared spectrum.

In this contribution, we will provide our views on detailed designs of on-demand SSB (OD-SSB) operation for SCell.

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## 2 Discussions

### 2.1 Whether to support Scenario 3B

In RAN1#116bis meeting [2], the following agreement was reached:

#### Agreement

- For the identified scenarios and cases (as per RAN1#116 agreement), on-demand SSB can be triggered by gNB at least for the following scenarios/cases:
  - Scenario #2 and Case #1
  - Scenario #2 and Case #2
  - Scenario #2A and Case #1
  - Scenario #2A and Case #2
  - FFS: Scenario #3A and Case #1
  - FFS: Scenario #3A and Case #2
  - FFS: Scenario #3B and Case #1
  - FFS: Scenario #3B and Case #2
  - For Case #1, once on-demand SSB is triggered, its transmission is in a periodic manner.
    - Note: This does not imply periodic on-demand SSB is transmitted indefinitely after triggered.
  - Notes:
    - Scenario #2A refers to
      - “When UE receives SCell activation command (e.g., as defined in TS 38.321)”
    - Scenario #3A refers to

- “After UE receives SCell activation command (e.g., as defined in TS 38.321) until SCell activation is completed”
- Scenario #3B refers to:
  - “When SCell activation is completed and SCell is activated” or
  - “After SCell activation is completed and SCell is activated”

Compared to other scenarios, an SCell can be operated in Scenario 3B for a long time. If the NW plans to use OD-SSB for an SCell, it inherently means that the NW wants to save energy consumption for the SCell. Then, it is more likely that the NW tends to not transmit too many CSI-RSs for SCell operation. Therefore, OD-SSB can be used as much as possible, e.g., for RRM and L1-RSRP measurement, in Scenario 3B, but only for Case #1.

**Proposal 1      Support Scenario 3B and at least Case #1 for on-demand SSB for SCell operation.**

## 2.2 L1-RSRP measurement based on OD-SSB

In RAN1#118 meeting [2], the following agreement was made regarding L1 measurement based on on-demand SSB.

### Agreement (RAN1#118)

- Update the previous RAN1 agreement as follows.
  - At least support L1 measurement based on on-demand SSB
    - For L1 measurement based on on-demand SSB, periodic, semi-persistent, [and aperiodic] L1 measurement reports based on existing CSI framework are supported.
      - FFS on potential enhancements of CSI report configuration and/or triggering/activation mechanisms for L1 measurement based on on-demand SSB
      - The support of LTM is a separate discussion point

### 2.2.1 L1/L3 measurement based on OD-SSB in Scenario 3B

In RAN1#117 meeting [3], the following agreements were reached:

### Agreement

- At least support L1 measurement based on on-demand SSB
  - For L1 measurement based on on-demand SSB, periodic, semi-persistent, [and aperiodic] L1 measurement reports based on existing CSI framework are supported.
    - FFS on potential enhancements of CSI report configuration and/or triggering/activation mechanisms for L1 measurement based on on-demand SSB.

### Agreement (Signalling)

For a cell supporting on-demand SSB SCell operation,

- Support RRC based signaling to indicate on-demand SSB transmission on the cell.
- Support MAC CE based signaling to indicate on-demand SSB transmission on the cell.
- FFS: Whether to support DCI based signaling to indicate on-demand SSB transmission on the cell.

- This DCI signaling does not provide SCell activation/deactivation.
  - If supported, details on DCI including UE-specific or group-common DCI, DCI contents, etc.
- FFS: Scenarios where the above signalings are applicable

Following the principle that the NW operating in NES would typically avoid transmitting too many CSI-RSs and OD-SSB can be used as much as possible for critical SCell operation. Therefore, we think that OD-SSB can be used for RRM measurement.

**Proposal 2      Support L3 measurement based on OD-SSB for SCell operation in Scenario 3B and Case #1.**

According to the current specifications, SSB used for RRM measurement can be within or outside the active DL BWP. If the UE performs RRM measurement based on OD-SSB, it also inherently performs L1-RSRP measurement on OD-SSB. Therefore, if the UE performs RRM measurement based on OD-SSB, it would be beneficial to also report the measured L1-RSRP. In the current specifications, a UE is not required to receive SSBs outside the active DL BWP for L1-RSRP measurement if the UE does not indicate support of *bwpOperationMeasWithoutInterrupt-r18*. Hence, if OD-SSB is triggered for L1-RSRP measurement in Scenario 3B, a single OD-SSB is configured per serving cell, and the OD-SSB is outside the active DL BWP, the UE cannot receive the valuable OD-SSB according to the current specifications.

**Observation 1    The UE cannot receive OD-SSB if the OD-SSB is outside the UE's active DL BWP in scenario 3B, i.e., SCell activation has been completed.**

There may be four kinds of solutions to the issue:

- **Solution #1: Ignoring the triggered OD-SSB if the triggered OD-SSB is outside the active DL BWP**
  - In this kind of solution, the UE ignores the triggered OD-SSB. However, according to the agreements made in RAN1#117, it is supported that OD-SSB can be triggered by RRC or MAC CE, which are UE-specific signaling. In our opinion, this kind of solution is not preferred because of waste of UE-specific signaling without cross-UE issues (e.g., Rel-15 pre-emption, Rel-16 UL cancellation indication).
- **Solution #2: Using measurement gap to perform OD-SSB-based L1-RSRP measurement**
  - In this kind of solution, a set of measurement gaps can be specified for OD-SSB-based L1-RSRP measurement. When OD-SSB is triggered, if the active DL BWP does not fully contain the OD-SSB, the UE uses the measurement gaps to perform L1-RSRP measurement.
- **Solution #3: Supporting BWP switch due to OD-SSB triggering**
  - In this kind of solution, the UE changes the active DL BWP (and the active UL BWP if TDD is used) after the UE receives the signaling that triggers OD-SSB to the DL BWP (and the active UL BWP) that fully contains the OD-SSB (if only a single OD-SSB configuration can be provided).
- **Solution #4: Supporting BWP-specific OD-SSB configuration**
  - In this kind of solution, an OD-SSB configuration can be configured in a per-BWP manner. Note that BWP-specific NCD-SSB has been introduced for RedCap since Rel-17. The gNB can determine whether to support OD-SSB-based L1-RSRP measurement on a given DL BWP.

Thus, we have the following proposals:

- Proposal 3** RAN1 to study whether and how to support OD-SSB-based L1 measurement in scenario 3B, taking BWP aspects into account.
- Proposal 4** RAN1 to study the following options for OD-SSB-based L1 measurement in scenario 3B in the cases where the triggered OD-SSB is outside the active DL BWP:
- **Solution #1: Ignoring the triggered OD-SSB**
  - **Solution #2: Using measurement gap to perform OD-SSB-based L1-RSRP measurement**
  - **Solution #3: Supporting BWP change due to OD-SSB triggering**
  - **Solution #4: Supporting BWP-specific OD-SSB configuration**

## 2.2.2 L1 Measurement configuration

In RAN1#118b meeting [3], the following agreement was made. Two options were discussed to configure CSI report configurations that are associated with OD-SSB.

### **Agreement (RAN1#118bis)**

For a cell supporting on-demand SSB SCell operation and for Case #2 (i.e., Always-on SSB is periodically transmitted on the cell), consider only one or both of the following options for UE to perform L1 measurement based on on-demand SSB.

- Option 1: A CSI report configuration is associated with both of on-demand SSB and always-on SSB
- Option 2: A CSI report configuration is associated with one of always-on SSB and on-demand SSB

FFS: Whether OD-SSB and always on SSB have same beam or not

In our view, Option 1 can be further classified into two sub-options:

- Option 1-1: Single CSI SSB resource set is configured to be associated with a CSI report configuration, which means the CSI SSB resource set refers to both always-on SSB and OD-SSB.
- Option 1-2: Multiple CSI SSB resource sets (for example, *csi-SSB-ResourceSetListExt2* can be introduced) are configured to be associated with a CSI report configuration, which means the network may configure some of the CSI SSB resource sets refer to always-on SSB and some of the CSI SSB resource sets refer to OD-SSB.

For Option 2, if a CSI report configuration is associated with OD-SSB, we understand the CSI SSB resource set that is associated with the CSI report configuration refers to OD-SSB.

Moreover, we think each option is applied to different deployment scenarios and OD-SSB configurations as listed below.

- **Case 2a:** We consider Case 2 where always-on SSB and OD-SSB are configured to be on **different** SSB frequency locations. In addition, always-on SSB and OD-SSB may have **the same or different** SSB indices (beams). It is noted that in the current 3GPP specification, the reference signals (i.e., CSI-SSB resource set(s)) that are associated with a CSI report configuration are all in the same SSB frequency location. Thus, when always-on SSB and OD-SSB are on different frequency locations, if a CSI report configuration is provided, the UE may need to identify whether it is dedicated for OD-SSB or always-on SSB. To achieve this, Option 2 can be adopted.
- **Case 2b:** We consider Case 2 where always-on SSB and OD-SSB are on the **same** SSB frequency but have **different** SSB indices (i.e., elements in *ssbPositionsInBurst* are different), which means it allows having different transmitted beams between OD-SSB and always-on SSB. For example, the SSB indices of OD-SSB may be a subset of the SSB indices of always-on SSB. The option to be applied may depend on the type of CSI report configuration.

- For a CSI report configuration, if only one CSI SSB resource set is configured to be associated with the CSI report configuration, Option 2 shall be adopted, which means the CSI SSB resource set is associated with either always-on SSB or OD-SSB.
- For a CSI report configuration, if two CSI SSB resource sets can be configured to be associated with the CSI report configuration, Option 1 (specifically, Option 1-2) can be adopted, which means one CSI SSB resource set is associated with always-on SSB, another one is associated with OD-SSB.
- **Case 2c:** We consider Case 2 where always-on SSB and OD-SSB are on the **same** frequency as well as both SSB have the **same** SSB indices (i.e., elements in *ssbPositionsInBurst* are configured to be identical). From the CSI SSB resource set perspective, there is no need to differentiate always-on SSB and OD-SSB; thus, Option 1 (specifically, Option 1-1) can be adopted.

**Table 1: Options applied to different deployment scenarios.**

Case 2 (always-on SSB and OD-SSB are configured for a SCell)	Different SSB frequency		Case 2a	Option 2
	Same SSB frequency	Different SSB indices	Case 2b	Option 1-2/2
		Same SSB indices	Case 2c	Option 1-1

**Proposal 5** For L1 measurement based on on-demand SSB, both Option 1 and Option 2 shall be supported depending on different deployment scenarios.

### 2.2.3 Report periodicity adaptation for Case 2

In the current 3GPP specifications, the CSI report configuration may provide a single report periodicity (e.g., *reportSlotConfig*) which is configured based on the periodicity of always-on SSB. When Option 1 is adopted, a CSI report configuration may be associated with always-on SSB and OD-SSB that have different periodicities, where the periodicity of always-on SSB may be configured to be longer than the periodicity of OD-SSB for NES gain. Thus, when OD-SSB is activated on a SCell, how UE reports OD-SSB based L1 measurement results for the SCell timely shall be studied. More specifically, for Option 1, we think the report periodicity for OD-SSB based measurement can be introduced within the CSI report configuration that is associated with both OD-SSB and always-on SSB. When OD-SSB is activated on the SCell, the UE uses the report periodicity for OD-SSB based measurement; otherwise, the UE use the report periodicity for always-on SSB based measurement.

**Proposal 6** For L1 measurement based on on-demand SSB, if Option 1 is supported, the report periodicity for OD-SSB based measurement is introduced within the CSI report configuration that is associated with both OD-SSB and always-on SSB.

Moreover, it is also noted that the UE may be configured with multiple periodicities for OD-SSB transmission on a SCell. In our view, to adapt the periodicity of OD-SSB, we think multiple report periodicities for OD-SSB based measurement can be configured within the CSI report configuration that is associated with OD-SSB (regardless of Option 1 or Option 2). To achieve this, multiple report periodicities may be provided within the CSI report configuration that is associated with OD-SSB. When the CSI report configuration is activated, if OD-SSB is activated, the UE may determine which report periodicity is used for OD-SSB based measurement reporting. The determination can be pre-configured by RRC signaling or indicated by the network via the OD-SSB activation signaling.

**Proposal 7** For L1 measurement based on on-demand SSB, regardless of Option 1 or Option 2, multiple report periodicities for OD-SSB based measurement are introduced within the CSI report configuration that is associated with OD-SSB.

## 2.2.4 Beam Failure Detection

In legacy, SSB is used for L1-RSRP/L1-SINR measurement, and the L1-RSRP measurement (result) is also used for RLM, BFD, etc. Considering it was agreed L1 measurement based on OD-SSB is supported, we think there is no harm to support OD-SSB based BFD. In addition, for Case 1, since only OD-SSB may be transmitted on the cell, for robustness purpose, OD-SSB based BFD shall be supported so that the network can be aware of channel quality of a Case 1 SCell. Regarding Case 2, always-on SSB may have a longer periodicity than that of OD-SSB to obtain NES gain. When OD-SSB with shorter periodicity is transmitted on the cell, the UE can benefit from quick beam failure detection based on OD-SSB. Moreover, if UE only uses OD-SSB for L1 measurement when OD-SSB is activated (i.e., Option 2 is used), OD-SSB based BFD shall be supported. Therefore, in our view, OD-SSB based BFD shall be supported for Case 2 SCell as well. Based on the analysis above, we propose OD-SSB based BFD is supported for both Case 1 and Case 2.

**Proposal 8**      **OD-SSB based BFD is supported for both Case 1 and Case 2.**

## 2.3 Whether on-demand SSB is CD-SSB or not

In previous RAN1 meetings, following agreements has been obtained for the SSB type applying OD-SSB.

### Agreement (RAN1#116bis)

- For a cell supporting on-demand SSB SCell operation,
  - Note: It is up to gNB implementation whether always-on SSB (if transmitted) on the cell is cell-defining SSB or not.
  - For on-demand SSB on the cell, downselect between the following alternatives
    - Alt-1: It is up to gNB implementation whether on-demand SSB is cell-defining SSB or not.
    - Alt-2: On-demand SSB is limited to non-cell-defining SSB.
      - FFS: Further limitations to on-demand SSB

### Agreement (RAN1#118)

For a cell supporting on-demand SSB SCell operation, at least the following is supported

- On-demand SSB on the cell is not located on synchronization raster.
- On-demand SSB on the cell is non-cell-defining SSB

FFS: Additional support of OD-SSB for CD-SSB located on sync-raster

In current specification, there is no restriction on SSB type used for SCell. Irrespective of whether the SSB is used for PCell for other UEs or not (i.e., SCell only), the SSB can be CD-SSB on sync raster. Although it may be up to NW implementation to transmit SIB1 in SCell, we don't need to exclude such scenarios. Therefore, we prefer to support OD-SSB SCell operation in any SSB type.

**Proposal 9**      **Support that OD-SSB can be CD-SSB located on sync raster.**

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## 3 Conclusions

Based on the discussion, we have the following observation and proposals:

**Proposal 1**      **Support Scenario 3B and at least Case #1 for on-demand SSB for SCell operation.**

**Proposal 2**      **Support L3 measurement based on OD-SSB for SCell operation in Scenario 3B and Case #1.**

<b>Observation 1</b>	<b>The UE cannot receive OD-SSB if the OD-SSB is outside the UE's active DL BWP in scenario 3B, i.e., SCell activation has been completed.</b>
<b>Proposal 3</b>	<b>RAN1 to study whether and how to support OD-SSB-based L1 measurement in scenario 3B, taking BWP aspects into account.</b>
<b>Proposal 4</b>	<b>RAN1 to study the following options for OD-SSB-based L1 measurement in scenario 3B in the cases where the triggered OD-SSB is outside the active DL BWP:</b> <ul style="list-style-type: none"> <li><b>Solution #1: Ignoring the triggered OD-SSB</b></li> <li><b>Solution #2: Using measurement gap to perform OD-SSB-based L1-RSRP measurement</b></li> <li><b>Solution #3: Supporting BWP change due to OD-SSB triggering</b></li> <li><b>Solution #4: Supporting BWP-specific OD-SSB configuration</b></li> </ul>
<b>Proposal 5</b>	<b>For L1 measurement based on on-demand SSB, both Option 1 and Option 2 shall be supported depending on different deployment scenarios.</b>
<b>Proposal 6</b>	<b>For L1 measurement based on on-demand SSB, if Option 1 is supported, the report periodicity for OD-SSB based measurement is introduced within the CSI report configuration that is associated with both OD-SSB and always-on SSB.</b>
<b>Proposal 7</b>	<b>For L1 measurement based on on-demand SSB, regardless of Option 1 or Option 2, multiple report periodicities for OD-SSB based measurement are introduced within the CSI report configuration that is associated with OD-SSB.</b>
<b>Proposal 8</b>	<b>OD-SSB based BFD is supported for both Case 1 and Case 2.</b>
<b>Proposal 9</b>	<b>Support that OD-SSB can be CD-SSB located on sync raster.</b>

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## 4 References

- [1] RP-242354, Revised WID: Enhancements of network energy savings for NR.
- [2] Chair's notes RAN1#116bis, April 17<sup>th</sup> – April 26<sup>th</sup>, 2024.
- [3] Chair's notes RAN1#117, May 20<sup>th</sup> – May 24<sup>th</sup>, 2024.
- [4] Chair's notes RAN1#118, August 19<sup>th</sup> – August 23<sup>rd</sup>, 2024.
- [5] Chair's notes RAN1#118bis, October 14<sup>th</sup> – August 18<sup>th</sup>, 2024.
- [6] Chair's notes RAN1#119, November 18<sup>th</sup> – November 22<sup>nd</sup>, 2024.