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Agenda item: **9.5.1**

Source: **Nokia, Nokia Shanghai Bell**

Title: **On-demand SSB SCell Operation**

Document for: **Discussion and Decision**

1 Introduction

In this contribution, we will discuss the cases, scenarios and signaling related to the on-demand SSB SCell operation. In companion contributions, we will discuss the issues on-demand SIB1 for idle/inactive mode UEs and adaptation of common signal/channel transmissions in [1][2].

2 On-demand SSB SCell operation for UEs in connected mode

2.1 Scenarios for on-demand SSB SCell operation

Regarding the scenarios for on-demand SSB SCell operation triggered by the gNB, the following agreement has been made in RAN1#116-bis meeting. In this section, we discuss the FFS aspects brought up during the RAN#116-bis meeting.

Agreement (RAN1#116bis)
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"
  - For discussion purpose under AI 9.5.1, always-on SSB is SSB supported in Rel-18 specifications.
- Timing for on-demand SSB transmission (e.g. when the triggered SSB starts and ends) will be separately discussed.

Agreement (RAN1#116)

For the following identified scenarios for on-demand SSB SCell operation, focus future RAN1 discussion to down-select (both may be selected) between the two scenarios.

- Scenario #2: SCell is configured to a UE but before the UE receives SCell activation command (e.g., as defined in TS 38.321)
- Scenario #3: After UE receives SCell activation command (e.g., as defined in TS 38.321)
  - This does not preclude SCell for which activation is completed
  - FFS: The case where SCell activation is completed

FFS: Application timing between NW triggering message and on demand SSB transmission

Based on the current understanding from the agreements, the Scenario#2, Scenario#2A, Scenario#3A and Scenario#3B are depicted in the diagram below. The time instances T1, T2 and T3 and Scenario references are taken from FL summary [4]:

- For Scenario#2: the on-demand SSB transmission can be triggered by gNB at the time instance T1 (i.e. at the time instance when UE receives SCell configuration via RRC message) or during the time period between T1 and T2.
- For Scenario#2A: the on-demand SSB transmission is triggered by gNB at the time instance T2 (i.e. at the time instance when UE receives SCell activation via MAC CE command).
- For Scenario#3A: the on-demand SSB transmission is triggered by gNB after the time instance T2 until SCell activation procedure is completed.
- For Scenario#3B: the on-demand SSB transmission can be triggered by gNB at the time instance T3 and after the time instance T3, i.e. when and after the SCell activation procedure is completed.

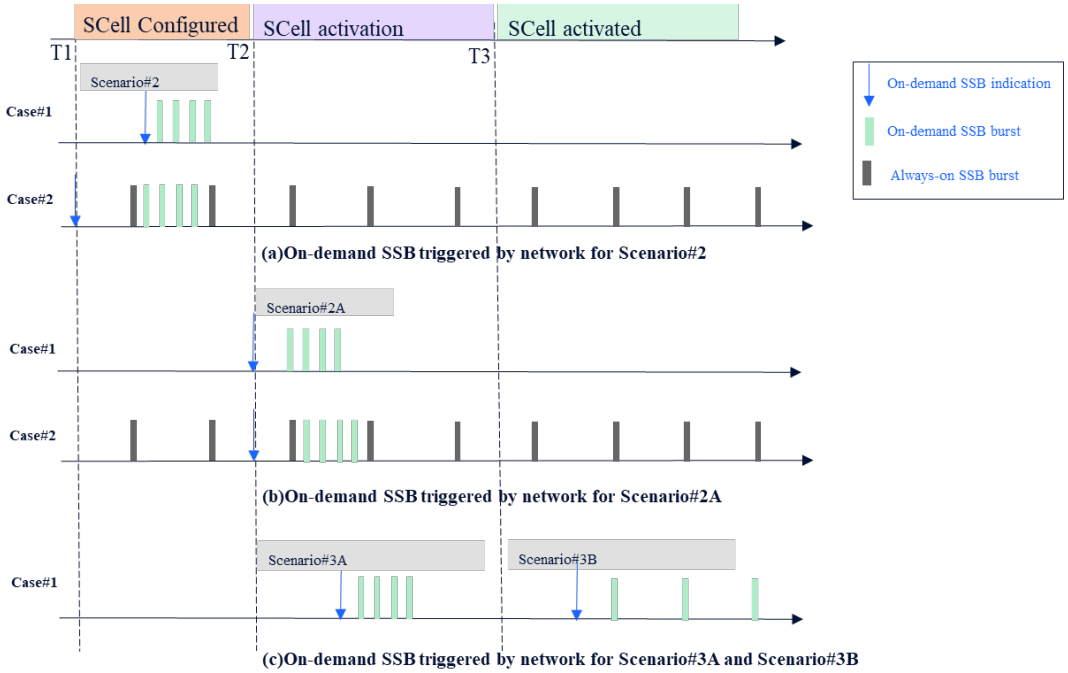

Figure 1: Scenarios for on-demand SSB operation.

Based on the agreement in RAN1#116bis, the Scenario#2 and Scenario#2A had been agreed for both Case #1 and Case #2. As indicated in our previous contribution [3], the NW triggering of on-demand SSB transmission with Scenario#2 can speed up the detection of the cell. And the NW triggering of on-demand SSB transmission in Scenarios#2A can also help to speed up the SCell activation procedure.

The Scenario#3A and Sceanrion#3B are FFS. To our view, Scenarion#2A is addressing the on-demand SSB operation during the SCell activation, and hence delaying the start of OD-SSB as in Scenario#3A seems redundant. During the RAN1#118 meeting it has also been agreed to support periodic, semi-persistent or aperiodic L1 measurement reporting based on on-demand SSB measurements. These L1-based measurement reports are provided from cells after the SCell activation procedure. Therefore, the Scenario#3B should also be supported and this needs to be confirmed by RAN1.

Proposal-1: RAN1 to confirm that Scenario#3B is supported for L1 measurements based on network triggered on-demand SSB.

2.4 Details on signaling for on-demand SSB SCell operation

Furthermore, regarding the RRC signaling for on-demand SSB, so far, the parameters indicating the frequency of on-demand SSB, periodicity of on-demand SSB, and SSB positions within an on-demand SSB burst have been agreed. We understand that for some parameters like absolute frequency, ssb-PositionsInBurst, ss-PBCH-BlockPower the value can be obtained from the legacy SSB configuration, e.g. with Case#2 when both always-ON SSB and OD-SSB are configured in the same frequency location. RAN1 may clarify this when RRC parameters of OD-SSB are discussed.

Observation-1: For some of the parameters like absolute frequency, ssb-PositionsInBurst, ss-PBCH-BlockPower the value can be obtained from legacy configuration if not explicitly provided with the on-demand SSB configuration, e.g. with Case#2 when both always-ON SSB and OD-SSB are configured in the same frequency carrier.

Proposal-2: RAN1 to clarify if/when the value of some of the parameters for on-demand SSB can be obtained from the legacy always-on SSB configuration.

2.5 On time/frequency/spatial relation between always-on SSB and OD-SSB:

2.5.1 On time location of OD-SSB

During the RAN1 #119 meeting, RAN1 could not agree on the time relationship between OD-SSB and always-on SSB.

Agreement

Response to **Q2** (What is the relation in terms of time location between always-on SSB and OD-SSB?) of Obj.1:

- RAN1 understands the time location of OD-SSB in Q2 refers to the time location of possible OD-SSB burst
- RAN1 is still discussing the relation in terms of time location between always-on SSB and OD-SSB

It has been agreed in RAN1#117 meeting that the time domain positions of on-demand SSBs within an OD-SSB burst should be configured by the network and the time locations of the OD-SSB bursts are known to UE. If the always-on SSB and OD-SSB are configured with the same half-frame index and same SFN offset, it may be possible that the time locations of OD-SSB transmissions with a shorter periodicity completely overlap with the time locations of always-on SSB transmissions, if the duration of OD-SSB transmission is long enough.

Moreover, it is still FFS whether the parameters that define time locations of OD-SSB transmissions are configured/indicated explicitly or not. To our view, for Case #1 without always-on SSB in the SCell as a reference, the time locations of OD-SSB bursts can be explicitly configured. But for Case#2, it should be considered that half-frame index and offset are the same as always-on SSB. For Case#2, the specification impact and UE complexity can be very much simplified if the time location of always-on SSB and OD-SSB is fully overlapped

in some of the time occasions, meaning that there is no transmission time offset between always-on SSB and OD-SSB, especially for the case when always-on SSB and OD-SSB are on the same frequency location.

Observation-2: It has been agreed in RAN1#117 meeting that the time domain positions of on-demand SSBs within SSB burst and the time locations of the OD-SSB bursts are known to UE.

Observation-3: For Case#2, when always-on SSB and OD-SSB are on the same frequency location the specification impact and UE complexity can be very much simplified if the time locations of always-on SSBs and OD-SSBs are fully overlapped in some of the time occasions, meaning that there is no transmission time offset between always-on SSB and OD-SSB.

Proposal-3: RAN1 answer to the Q2 of OD-SSB is: When always-on SSB and OD-SSB are on the same frequency location, they are configured so that SFN offset and half frame index are the same. However, when they are in different frequency location, there are no limitations on the time location configuration.

2.5.2 On frequency location of OD-SSB and BWP aspects

In RAN1#118 and RAN1#119 meetings, the following agreements have been made:

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

Agreement
Response to Q3 (What is the relation in terms of frequency location between the always-on SSB and OD-SSB?) of Obj.1:
- The frequency location of on-demand SSB is the same as the frequency location of always-on SSB at least for the case where always-on SSB is not CD-SSB. RAN1 is discussing the frequency location of OD-SSB for the case where always-on SSB is CD-SSB.

Agreement
Down-select at least one of the following alternatives.
- Alt 1: If always-on SSB is CD-SSB on a synchronization raster, the frequency location of on-demand SSB is different from the frequency location of always-on SSB.
- Alt 2: If always-on SSB is CD-SSB on a synchronization raster, the frequency location of on-demand SSB is the same as the frequency location of always-on SSB.
- Alt 3: Do not support the case where always-on SSB is CD-SSB on a synchronization raster.

Down-select at least one of the following alternatives.
- Alt A: If always-on SSB is CD-SSB and not on a synchronization raster, the frequency location of on-demand SSB can be same or different from the frequency location of always-on SSB, subject to its configuration.
- Alt B: If always-on SSB is CD-SSB and not on a synchronization raster, the frequency location of on-demand SSB is the same as the frequency location of always-on SSB.
  Alt C: Do not support the case where always-on SSB is CD-SSB and not on a synchronization raster.

As per the RAN1 agreements, OD-SSB may be non-cell defining and off the synchronization raster. Whether OD-SSB can be cell defining and on synchronization raster is not yet clarified. The always-on CD-SSB transmitted on a synchronization raster seems to be the most likely configuration supported in most networks.

When always-on CD-SSB is transmitted on sync-raster and considering the agreement that at least OD-SSB that is NCD-SSB not located on the synchronization raster is supported, it seems clear that operation according to Alt1 should be supported. Our understanding is that in this case always-on SSB and OD-SSB are configured to different BWPs.

Moreover, as per the current specification, UE may be configured with multiple SSBs provided that each BWP is configured with at most one SSB (CD-SSB or NCD-SSB). When the network configures always-on SSB as CD-SSB, then as per the current requirement, OD-SSB would need to be on same frequency location as always-on SSB. This corresponds to Alt 2 above and in this case OD-SSB should be cell defining SSB.

Observation-4: Network may configure always-on SSB as CD-SSB. If OD-SSB is on the same BWP as always-on SSB, it should be in the same frequency as always-on SSB because of the requirement that at most one SSB can be configured with each BWP. Alt 2 should therefore be supported and OD-SSB should then be CD-SSB. This scenario can be viewed as the CD-SSB periodicity adaptation in SCell and this could also be discussed along with Objective#3.

Observation-5: We see that both Alt1 and Alt2 are possible configurations when always-on SSB is CD-SSB transmitted on a synchronization raster.

The network may configure always-on CD-SSB that is not on a synchronization raster but all the UEs cannot find that kind of SSB, obtain SI of the cell and access the cell, if the CD-SSB frequency location is not configured for them. For simplification of the options and progress towards a feasible solution, we can deprioritize this case and hence we prefer Alt C.

Observation-6: For simplification of the options and progress towards a feasible solution, we can deprioritize the case when always-on SSB is CD-SSB not in the synchronization raster and hence we prefer Alt C.

Proposal-4: RAN1 prioritizes the case when always-on CD-SSB is transmitted on synchronization raster. Support both Alt-1 and Alt-2.

Furthermore, when multiple SSBs (always-on and OD-SSB) are provided in difference frequency location, how they are placed with respect to the BWP becomes critical. Whether or not the UE is able to measure always-on SSB and/or OD-SSB may depend on the UE bandwidth capability and the frequency location of OD-SSB. For example, in Rel-18 as part of the BWP without restriction feature, the UE capability ***bwpOperationMeasWithoutInterrupt-r18*** was introduced. It indicates UE support for RLM/BM/BFD and gapless L3 intra-frequency measurements based on CD-SSB outside active BWP without interruptions. And in this case, the assumption is that CD-SSB is outside active DL BWP but within UE channel bandwidth. For the ongoing discussions related to frequency location of OD-SSB, currently it is still unclear on whether the OD-SSB need to be available to the UE within the active bandwidth part or it can be outside the active bandwidth part.

Observation-7: It may depend on the UE bandwidth capability, the ability to measure SSB outside the active BWP and the location of OD-SSB, if the UE is able to measure both always-on and OD-SSB.

Proposal-5: RAN1 to discuss the UE capabilities needed to measure OD-SSB within or outside active BWP.

Further from the signaling perspective, whether the OD-SSB configuration is BWP specific or cell-specific shall be discussed and clarified in RAN1 for RAN2 to progress with the signaling details.

Proposal-6: For Case#2, RAN1 to discuss whether or not UE can be configured with both always-on SSB and OD-SSB transmissions in the same BWP. And if OD-SSB configuration will be BWP-specific or cell-specific.

2.6 On timing for on-demand SSB transmission

Regarding the timing for on-demand SSB transmission, the following agreement has been made in RAN1#116bis and RAN1#118 meetings.

Agreement RAN1#118-bis

The previous RAN1 agreement is partly confirmed and further revised as follows.

- For SSB burst(s) indicated by on-demand SSB SCell operation via a MAC CE, UE expects that on-demand SSB ~~burst(s)~~ is transmitted from time instance A which is determined as follows.
  - Alt 3-1: Time instance A is the beginning of the first slot containing ~~[candidate SSB index 0 or~~ the first actually transmitted SSB index~~]~~ ~~of~~within the first "possible" on-demand SSB burst which is at least T slots after the slot where UE receives a signalling from gNB to indicate on-demand SSB transmission
    - The SSB time domain positions of on-demand SSB burst are configured by gNB.
      - The location(s) (e.g., SFN offset, half frame index) in the time domain of "possible" on-demand SSB burst and SSB position within the burst should be configured by the gNB
  - Note: The value of T is not less than existing timeline required for UE's MAC CE processing for SCell activation
  - (Working assumption): T is not less than T_min=$m + 3N_{slot}^{subframe,\mu}$+1 where slot n+m is a slot indicated for PUCCH transmission with HARQ-QCK information when the UE receives MAC CE signaling to indicate on-demand SSB transmission ending in slot n, and $N_{slot}^{subframe,\mu}$ is as defined in current specification.
    - RAN4 to confirm that T_min can be equal to $m + 3N_{slot}^{subframe,\mu}$+1
  - (Working assumption) T=T_min
- Above applies at least for the case where SCell with on demand SSB transmission and cell with signalling transmission have the same numerology.

Agreement

The following agreement from RAN1#116 is modified (in red)

- For SSB burst(s) ~~triggered~~indicated by on-demand SSB SCell operation, study at least the following options.
  - Option 1: UE expects that on-demand SSB burst(s) is periodically transmitted from time instance A.
  - Option 1A: UE expects that on-demand SSB burst(s) is periodically transmitted from time instance A until gNB turns OFF the on demand SSB
  - Option 2: UE expects that on-demand SSB burst(s) is transmitted from time instance A to time instance B and not transmitted after time instance B.
  - Option 3: UE expects that on-demand SSB burst(s) is transmitted N times after time instance A and not transmitted after N on-demand SSB bursts are transmitted.
  - Option 4: UE expects that on-demand SSB burst(s) is transmitted with a periodicity from time instance A to time instance B and with the other periodicity after time instance B.
  - FFS: The combination of above options
  - FFS: How to define time instance A/B and the value of N per option
  - FFS: Each option is applicable to which Cases or Scenarios (as per the previous agreement)

- **On time instance A: (starting time of OD-SSB transmission)**

As per the discussion during the RAN1#118 meeting, T is not less than T_min=$m + 3N_{slot}^{subframe,\mu}$+1 where slot n+m is a slot indicated for PUCCH transmission with HARQ-QCK information when the UE receives MAC CE signaling to indicate on-demand SSB transmission ending in slot n. It is indicated in the agreement that these timing requirements apply at least for the case where SCell with on demand SSB transmission and cell with signaling transmission have the same numerology. It has to be noted that the time reference and numerology being indicated in these equations are with respect to the carrier on which UE receives MAC-CE and is independent of the SCell numerology.

Observation-8: The numerology considered for the T_min calculations are with respect to the carrier on which UE receives MAC-CE.

Proposal-7: RAN1 to confirm that the agreement on the T slots apply to the cell transmitting the MAC-CE signaling and applies irrespective of the SCell numerology.

However, for the RRC-based signaling, in practice it is not accurately known in advance the exact time slot when the RRC message can be scheduled and received by a UE. Thus, the UE cannot assume the time slot of RRC signaling reception as time reference for the first SSB time domain position. Instead, the slot/SFN-based timing indication in PCell can be considered as the time reference for the first SSB time domain position. Also, it is most

probable that the UE does not have the time synchronization yet with SCell, e.g Scenario#2 or Scenario#2A, and the time when UE may start monitoring for OD-SSB of SCell needs to be referenced with respect to PCell SFN.

Observation-9: UE cannot assume the time slot of RRC signaling reception as the time reference for the first OD-SSB time domain position.

Proposal-8: For RRC-based signaling to activate the on-demand SSB transmission, the time reference for the first SSB time domain position can be based on the slot and system frame number in PCell.

2.6.1 On Deactivation of on-demand SSB

Agreement RAN1#119
For a cell supporting on-demand SSB SCell operation, support at least the following options to deactivate on-demand SSB transmission from a UE perspective.

- Option 1: Explicit indication of deactivation for on-demand SSB via MAC-CE for on-demand SSB transmission indication
  - Deactivation by RRC is up to RAN2
  - FFS: Which scenario Option 1 is used
- Option 2: Configuration/indication of the number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated
  - FFS: Whether Option 4, 4a is needed in addition to Option 2
  - FFS: Whether the value of N can be implicitly determined using a timer

Agreement RAN1#118-bis

For a cell supporting on-demand SSB SCell operation, deactivation of on-demand SSB transmission is supported. In order to deactivate on-demand SSB transmission from a UE perspective, support at least one of the following options.

- Option 1: Explicit indication of deactivation for on-demand SSB via MAC-CE for on-demand SSB transmission indication
- Option 1A: Explicit indication of deactivation for on-demand SSB via RRC for on-demand SSB transmission indication
- Option 2: Configuration/indication of the number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated
- Option 3: Configuration/indication of the duration of on-demand SSB transmission window
- Option 4: On-demand SSB transmission, if any, is deactivated when UE receives SCell deactivation MAC-CE for the activated SCell
- Option 4A: On-demand SSB transmission, if any, is deactivated when the timer for SCell deactivation is expired
- Option 5: On-demand SSB transmission, if any, is deactivated when SCell activation is completed
- Option 6: Explicit indication of deactivation for on-demand SSB via [group-common] DCI
- FFS: Each option is applicable to which Cases or Scenarios
- FFS: Details related to each of the above options

In the RAN1#119 meeting two methods to deactivate OD-SSB transmission was agreed. Considering specification and implementation complexity, additional deactivation options should not be supported. Regarding the scenarios for MAC-CE based deactivation, we do not see that this method should be limited to a specific scenario.

In Option 2 there is no difference whether the duration of OD-SSB transmission is determined based on the number N of OD-SSB bursts and the periodicity of OD-SSB or it is determined based on the timer. RAN4 is probably going to define some (periodicity dependent) detection time requirements for OD-SSB reception and because of that timer-based operation may be preferable.

When network activates OD-SSB transmission, it may not know, how long the OD-SSB transmission will last. Network may then configure the number N of OD-SSB bursts (or equivalently a timer) to a high value (infinite could be one configuration option) and send MAC-CE OD-SSB deactivation command when OD-SSB transmission are discontinued. Regarding the question if UE should consider OD-SSB deactivated when it receives SCell deactivation command, we think that this type of additional function for the SCell activation command is not needed. In some specific cases this could save transmission of one MAC-CE command but on the other network may want that UE is aware that OD-SSB is still transmitted even after SCell is deactivated.

Proposal-9: Besides Option 1 and Option 2 no other options are specified for OD-SSB deactivation

Proposal-10: In Option 2 the duration of OD-SSB transmission can be based on timer and the value of N is then determined implicitly.

2.7 L1 measurements based on on-demand SSB

In RAN1#118 meeting, the following has been agreed on L1 measurements 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

Agreement (RAN1#118-bis)

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

- **Operation scenario for L1 measurements based on on-demand SSB**

L1 measurements based on on-demand SSB has been agreed but it is still unclear in which scenarios they are considered. Whether the L1 reporting is referring to the CSI reporting during the SCell activation procedure or L1 reporting in the activated SCell is to be clarified.

Observation-10: L1 measurements based on on-demand SSB has been agreed but it is still unclear in which scenarios it is to be considered, i.e. whether the L1 reporting is referring to the CSI reporting during the SCell activation procedure or L1 reporting in the activated SCell.

Proposal-10: RAN1 to discuss and clarify the operation scenario for L1 measurements based on OD-SSB.

- **On resource configuration for L1 measurements based on on-demand SSB**

Moreover, practically the L1-based measurements within the SCell may be configured for beam management. The existing CSI measurement framework supports SSB-based L1-RSRP or L1-SINR measurements and reporting. The UE may be configured with *CSI-ResourceConfig* that contains,

- A list of NZP CSI-RS resource set and/or SSB resource set provided by *nzp-CSI-RS-ResourceSetList* and/or *csi-SSB-ResourceSetList*
- Or a list of CSI-IM resource set provided by *csi-IM-ResourceSetList*

Especially for the L1-SINR measurements, the UE requires to be configured with two Resource Settings one for channel measurement (based on SSB/NZP CSI-RS resource set) and another for interference measurement (based on CSI-IM resource or NZP CSI-RS for Interference measurement). Therefore, it requires to have a one-to-one mapping of the resources configured for channel measurement (SSB or NZP-CSI-RS) and resources configured for interference measurement (CSI-IM or NZP-CSI-RS) as specified in TS38.214 section 5.2.1.2.

Generally, the CSI resources are associated with a DL BWP. For the SSB-based L1 measurements, the RAN1 description as per TS38.214 is as below:

If the UE is configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'ssb-Index-RSRP' or 'ssb-Index-RSRP- Index', the UE shall report SSBRI, where SSBRI k ($k \geqslant 0$) corresponds to the configured (k+1)-th entry of the associated *csi-SSB-ResourceList* in the corresponding *CSI-SSB-ResourceSet.*

The *csi-SSB-ResourceList* is the list of *SSB-Index* values and *SSB-Index* identifies an SS-Block within an SS-Burst. The SSB Resource Indicator is indication to the SSB within a SS-burst.

Based on the discussions above, our understanding is the OD-SSB burst may be configured with dedicated *ssbPositions-InBurst* bitmap. The existing structure for csi-SSB-ResourceSet seems to be sufficient for OD-SSBs and we do not see a need to modify the Resource setting.

Observation-11: The CSI resources are associated with a DL BWP. As per the current specification, the csi-SSB-ResourceList is the list of SSB-Index values which identify an SS-Block within the SSB burst. We do not see the need to modify the Resource setting.

- **<u>Report configuration for L1 measurements based on on-demand SSB</u>**

Regarding the report configuration according to TS 38.331, it is expected that the IE *CSI-ReportConfig* is used to configure the time domain behavior of a periodic or semi-persistent report sent on PUCCH, or to configure a semipersistent or aperiodic report sent on PUSCH triggered by DCI received on the cell in which the *CSI-ReportConfig* is included (in this case, the cell on which the report is sent is determined by the received DCI). See TS 38.214 [19], clause 5.2.1.

Considering the SCell activation scenario, for the L1 measurement based on OD-SSB for the activated SCells, the periodic or semi-persistent reporting may be configured with the OD-SSB that is periodically available once being triggered, and the MAC CE used for triggering OD-SSB transmission can be also considered as trigger for CSI reporting associated with the OD-SSB resources.

Observation-12: For L1 measurements based on OD-SSB for the activated SCells, the periodic or semi-persistent reporting may be configured with the OD-SSB that is periodically available once being triggered.

Proposal-11: The MAC CE used for triggering OD-SSB transmission can also be considered as the trigger for the CSI reporting associated with OD-SSB resources.

Furthermore, when both always-on SSB and OD-SSB are configured how does the UE perform L1 measurement and reporting should be discussed. Our understanding is that there is one-to-one mapping of always-on SSB beams and OD-SSB beams. If L1 measurements are enabled for OD-SSB, always-on SSB based measurements may not be required. Moreover, the gNB may configure a dedicated CSI report configuration that is associated with OD-SSB with a shorter reporting periodicity, if network requires quick L1 reports based on OD-SSB. Although, the purpose of such L1 reports is not yet clear to us. It is to be further discussed if OD-SSB would have a dedicated report configuration.

Observation-13: gNB may configure a dedicated CSI report configuration associated with OD-SSB possibly with a shorter reporting periodicity, if network requires quick L1 reports based on OD-SSB

Proposal-12: RAN1 to discuss if OD-SSB would have a dedicated report configuration associated with OD-SSB transmission.

For the aperiodic reporting, DCI 0_x formats that provide the aperiodic Triggering state, are supported. The current framework shall be sufficient to handle aperiodic reporting based on on-demand SSB. Although it is still not clear when and for what purpose the gNB may enable aperiodic reporting for on-demand SSB based measurements. Considering the SCell activation scenario, we don't see the benefits from the network energy saving perspective for gNB sending the additional DCI signaling for triggering such OD-SSB based aperiodic reporting, as it increases network energy consumption.

Observation-14: It is still not clear when and for what purpose the gNB may enable aperiodic reporting for on-demand SSB based measurements.

Observation-15: Considering the SCell activation scenario, we don't see the benefits from the network energy saving perspective for gNB sending the additional DCI signaling for triggering OD-SSB based aperiodic reporting, as it increases network energy consumption.

Proposal-13: RAN1 to discuss and clarify the scenario for utilizing OD-SSB based aperiodic reporting.

Furthermore, considering Case 2 with OD-SSB on top of always-on SSB on SCell, RAN1 shall discuss on how to handle the CSI reporting when both always-on SSB and OD-SSB are received, i.e. shall the UE reporting consist of both CSI reports, or shall the UE send only one of the CSI reports.

Proposal-14: Considering Case 2 with OD-SSB on top of always-on SSB on SCell, RAN1 shall discuss on how to handle the CSI reporting when both always-on SSB and OD-SSB are applied, i.e. shall the UE reporting consist of both reports, or shall the UE report only one of the CSI reports.

LTM is used to help UEs move smoothly between cells based on L1 measurements. It may require frequent measurements to work well and always-on SSB seems to suit better than the on-demand SSB. Also to note that LTM has its own CSI Report configuration IEs for the measurement and reporting. If RAN1 decides to enhance CSI-Reporting framework for on-demand SSB based L1 measurements for SCells, similar changes could also be applied to LTM settings. However, RAN1 discussions should focus on supporting SCell operation for UEs in connected mode configured with CA and we would like to keep mobility measurements and LTM out of scope of on-demand SSB.

Proposal-15: On-demand SSB work is intended to enhance SCell operation, and we propose to keep mobility measurements and LTM out of scope of on-demand SSB.

3 Conclusions

In this contribution, we have the following observations and proposals:

Proposal-1: RAN1 to confirm that Scenario#3B is supported for L1 measurements based on network triggered on-demand SSB.

Observation-1: For some of the parameters like absolute frequency, *ssb-PositionsInBurst*, *ss-PBCH-BlockPower* the value can be obtained from legacy configuration if not explicitly provided with the on-demand SSB configuration, e.g. with Case#2 when both always-ON SSB and OD-SSB are configured in the same frequency carrier.

Proposal-2: RAN1 to clarify if/when the value of some of the parameters for on-demand SSB can be obtained from the legacy always-on SSB configuration.

Observation-2: It has been agreed in RAN1#117 meeting that the time domain positions of on-demand SSBs within SSB burst and the time locations of the OD-SSB bursts are known to UE.

Observation-3: For Case#2, when always-on SSB and OD-SSB are on the same frequency location the specification impact and UE complexity can be very much simplified if the time locations of always-on SSBs and OD-SSBs are fully overlapped in some of the time occasions, meaning that there is no transmission time offset between always-on SSB and OD-SSB.

Proposal-3: RAN1 answer to the Q2 of OD-SSB is: When always-on SSB and OD-SSB are on the same frequency location, they are configured so that SFN offset and half frame index are the same. However, when they are in different frequency location, there are no limitations on the time location configuration.

Observation-4: Network may configure always-on SSB as CD-SSB. If OD-SSB is on the same BWP as always-on SSB, it should be in the same frequency as always-on SSB because of the requirement that at most one SSB can be configured with each BWP. Alt 2 should therefore be supported and OD-SSB should then be CD-SSB. This scenario can be viewed as the CD-SSB periodicity adaptation in SCell and this could also be discussed along with Objective#3.

Observation-5: We see that both Alt1 and Alt2 are possible configurations when always-on SSB is CD-SSB transmitted on a synchronization raster.

Observation-6: For simplification of the options and progress towards a feasible solution, we can deprioritize the case when always-on SSB is CD-SSB not in the synchronization raster and hence we prefer Alt C.

Proposal-4: RAN1 prioritizes the case when always-on CD-SSB is transmitted on synchronization raster. Support both Alt-1 and Alt-2.

Observation-7: It may depend on the UE bandwidth capability, the ability to measure SSB outside the active BWP and the location of OD-SSB, if the UE is able to measure both always-on and OD-SSB.

Proposal-5: RAN1 to discuss the UE capabilities needed to measure OD-SSB within or outside active BWP.

Proposal-6: For Case#2, RAN1 to discuss whether or not UE can be configured with both always-on SSB and OD-SSB transmissions in the same BWP. And if OD-SSB configuration will be BWP-specific or cell-specific.

Observation-8: The numerology considered for the T_min calculations are with respect to the carrier on which UE receives MAC-CE.

Proposal-7: RAN1 to confirm that the agreement on the T slots apply to the cell transmitting the MAC-CE signaling and applies irrespective of the SCell numerology.

Observation-9: UE cannot assume the time slot of RRC signaling reception as the time reference for the first OD-SSB time domain position.

Proposal-8: For RRC-based signaling to activate the on-demand SSB transmission, the time reference for the first SSB time domain position can be based on the slot and system frame number in PCell.

Proposal-9: Besides Option 1 and Option 2 no other options are specified for OD-SSB deactivation

Proposal-10: In Option 2 the duration of OD-SSB transmission can be based on timer and the value of N is then determined implicitly.

Observation-10: L1 measurements based on on-demand SSB has been agreed but it is still unclear in which scenarios it is to be considered, i.e. whether the L1 reporting is referring to the CSI reporting during the SCell activation procedure or L1 reporting in the activated SCell.

Proposal-10: RAN1 to discuss and clarify the operation scenario for L1 measurements based on OD-SSB.

Observation-11: The CSI resources are associated with a DL BWP. As per the current specification, the csi-SSB-ResourceList is the list of SSB-Index values which identify an SS-Block within the SSB burst. We do not see the need to modify the Resource setting.

Observation-12: For L1 measurements based on OD-SSB for the activated SCells, the periodic or semi-persistent reporting may be configured with the OD-SSB that is periodically available once being triggered.

Proposal-11: The MAC CE used for triggering OD-SSB transmission can also be considered as the trigger for the CSI reporting associated with OD-SSB resources.

Observation-13: gNB may configure a dedicated CSI report configuration associated with OD-SSB possibly with a shorter reporting periodicity, if network requires quick L1 reports based on OD-SSB

Proposal-12: RAN1 to discuss if OD-SSB would have a dedicated report configuration associated with OD-SSB transmission.

Observation-14: It is still not clear when and for what purpose the gNB may enable aperiodic reporting for on-demand SSB based measurements.

Observation-15: Considering the SCell activation scenario, we don't see the benefits from the network energy saving perspective for gNB sending the additional DCI signaling for triggering OD-SSB based aperiodic reporting, as it increases network energy consumption.

Proposal-13: RAN1 to discuss and clarify the scenario for utilizing OD-SSB based aperiodic reporting.

Proposal-14: Considering of Case 2 with OD-SSB on top of always-on SSB on SCell, RAN1 shall discuss on how to handle the CSI reporting when both always-on SSB and OD-SSB are applied, i.e. shall the UE reporting consist of both reports, or shall the UE report only one of the CSI reports.

Proposal-15: On-demand SSB work is intended to enhance SCell operation, and we propose to keep mobility measurements and LTM out of scope of on-demand SSB.

4 References

[1] R1-2500477, "On-demand SIB1 for Idle Inactive mode UEs", Nokia, Nokia Shanghai Bell, RAN1#120, Athens, Greece, February 17th – 21st, 2025.

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