3GPP TSG-RAN WG1 Meeting #120 **Tdoc R1-2501251**
Athens, Greece, February 17th – February 21st, 2025

Agenda Item: **9.5.1**

Source: **Ericsson**

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

Document for: **Discussion**

1 Introduction

The WID for NR Rel-19 “Enhancements of network energy savings for NR” [1] states the following:

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.
   - 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)
   - Note: 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 provide our views and proposals for the above Objective 1.

2 Discussion

2.1 On-demand SSB deactivation

In RAN1#118, it was agreed that MAC CE signaling can be used to indicate that on-demand SSB transmission is turned ON in an SCell for both Case #1 and Case #2, and for both Scenario #2 and #2A, where, as per previous agreements:

- Case #1 refers to
  - “No always-on SSB on the cell”
- Case #2 refers to
  - “Always-on SSB is periodically transmitted on the cell”.

Here, always-on SSB refers to legacy SSB, i.e., SSB that is semi-statically provided in the SCell. Furthermore,

- Scenario #2 refers to
  - “SCell is configured to a UE but before the UE receives SCell activation command (e.g., as defined in TS 38.321)”.
- Scenario #2A refers to
  - “When UE receives SCell activation command (e.g., as defined in TS 38.321)”.

In addition, it has been agreed that RRC signaling can indicate that on-demand SSB transmission is turned ON upon SCell configuration.

How to indicate that on-demand SSB transmission is turned OFF in an SCell is an open issue. In RAN1#119, it was agreed that at least two options can turn OFF an on-demand SSB transmission:

Agreement
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

Here, as per previous agreements:

- Option 4 refers to
  - "On-demand SSB transmission, if any, is deactivated when UE receives SCell deactivation MAC-CE for the activated SCell"
- Option 4A refers to
  - "On-demand SSB transmission, if any, is deactivated when the timer for SCell deactivation is expired"

The NW should have the flexibility to explicitly deactivate on-demand SSB if it is no longer needed, which may be while the SCell is in a deactivated state (e.g., on-demand SSB is turned OFF after UE has sent a measurement report associated with deactivated SCell measurements) or while the SCell is in an activated state (e.g., on-demand SSB is turned OFF at the same time as the SCell is deactivated).

Proposal 1 **Support Option 1 for both deactivated and activated SCells.**

Whether a new MAC CE for on-demand deactivation can additionally deactivate the SCell is an open question, which is discussed in RAN2. In our view, since on-demand SSB and SCell activation at the same time, i.e., Scenario #2A, is supported, it makes sense to support also on-demand SSB and SCell deactivation at the same time. In this case, the functionality of Option 4 can be supported by Option 1, e.g., using a bit in MAC CE for on-demand SSB deactivation to indicate that one or more SCells should also be deactivated.

Observation 1 **The functionality of Option 4 can be realized by Option 1 if a MAC CE that deactivates the on-demand SSB can also deactivate the SCell.**

An open question is whether timer-based SCell deactivation can be supported with Option 2. It is common understanding that UE requires some type of SSB (always-on SSB and/or on-demand SSB) while the UE's SCell's is in an active state. This potentially poses a problem with Option 2 for the case when there is no always-on SSB in the cell, i.e., Case #1. Indeed, as the SCell deactivation may be renewed at any time and an arbitrary number of times, there is no finite number *N* that can guarantee that on-demand SSB is provided for the entirety of the SCell's active period.

One possible way to remedy this issue is to restart (or, rather, prolong) the on-demand SSB transmission period each time the SCell deactivation timer is restarted. In this way, as long as the on-demand SSB provision duration is at least as long as SCell deactivation timer, UE can be ensured that on-demand SSB is always provided while the SCell is activated.

Proposal 2 **Support restarting or prolonging an on-demand SSB transmission at the same time as the SCell deactivation timer is restarted.**

Observation 2 **The functionality of Option 4A can be realized by Option 2 if the on-demand-SSB transmission is restarted when the SCell deactivation timer is restarted.**

In our view, with the above proposals, there is no need to any other mechanisms in addition to Option 1 and Option 2 for SCell deactivation.

2.2 On-demand SSB adaptation

In RAN1#118, it was agreed that a number of candidate SSB periodicities can be configured by RRC, and MAC CE can be used to indicate which of the candidates that is activated.

> **Agreement**
> For a cell supporting on-demand SSB SCell operation, at least for the following parameter(s), multiple candidate values can be configured by RRC and the applicable value can be indicated by MAC CE for on-demand SSB transmission indication for the cell.
>
> - Periodicity of the on-demand SSB
> - FFS: Any other relevant parameters

In this section, we discuss dynamic indication of on-demand SSB configurations in line with this agreement.

We think that the MAC CE that provides the on-demand SSB periodicity (and any other potential parameters) per SCell, can also indicate whether the on-demand SSB is turned ON/OFF for that particular SCell. This way, NW avoids having to send multiple MAC CEs, which would cause increased signaling overhead and may cause increased SCell activation delay.

Proposal 3 **Support NW providing on-demand SSB transmission indication (i.e., that SSB is turned ON or OFF) and on-demand SSB configuration indication (e.g., SSB periodicity) at the same time.**

Only one configuration is allowed to be active at a given time per SCell. If UE receives a MAC CE indicating that SSB is turned ON with periodicity P1 at time T1 and SSB is turned ON with periodicity P2 at a time T2, UE can assume that SSB is transmitted with periodicity P2 at time instance A after time T2.

Proposal 4 **An on-demand SSB transmission indication for an SCell (e.g., ON/OFF or parameter change) overrides a potentially ongoing on-demand SSB transmission configuration for that SCell.**

2.2.1 Adaptation of on-demand SSB periodicity

The main motivation for supporting dynamic indication of periodicity is that on-demand SSB may need to be provided at different rates depending on the state of the UE. The periodicity value for on-demand SSB is according to the below agreement from RAN1#119.

> **Agreement**
> New periodicity value for on-demand SSB other than the legacy values (i.e., 5 ms, 10 ms, 20 ms, 40 ms, 80 ms, or 160 ms) is NOT introduced in Rel-19.

For the scenario where UE receives SCell activation command and on-demand SSB transmission indication at the same time (i.e., Scenario #2A) and when there is no always-on SSB present in the SCell (i.e., Case #1), UE has to rely on on-demand SSB for, e.g., time/frequency synchronization and AGC adjustment. Thus, as shown in Figure 1, on-demand SSB needs to be provided at a relatively fast rate (e.g., 10 ms) for the SCell activation delay not to be excessively large. However, once SCell activation is completed, SSB may be used only for RRM measurements, which implies that it can be provided at a relatively slow rate (e.g., 160 ms), enabling further network energy saving gains.

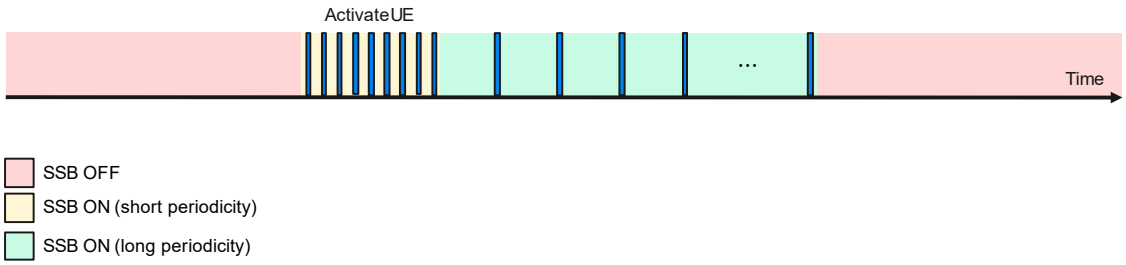

Figure 1 **Example of on-demand SSB periodicity adaptation with a single UE in the SCell.**

To support the behavior illustrated in Figure 1, on-demand SSB periodicity adaptation should be supported while SCell is in an activated state. If the same MAC CE is used for both on-demand SSB transmission

indication and parameter adaptation as per Proposal 3 and Proposal 4, and if NW can adapt SSB periodicity while SCell is activated, a consequence is that UE should be able to receive said MAC CE while SCell is in an activated state. So far, MAC CE signaling for on-demand SSB transmission indication is supported only for Scenario #2 and #2A, and whether Scenario #3A and Scenario #3B should be also supported is FFS, where, as per previous agreements:

- 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".

In our view, there is limited benefit with performing SSB periodicity adaptation for Scenario #3A. Indeed, as this is a short transition phase, network energy saving gains would be marginal at the cost of increased SCell activation delay. Therefore, supporting MAC CE signaling for Scenario #3B may be sufficient.

Proposal 5 **Support adaptation of on-demand SSB periodicity via MAC CE while SCell is in an activated state, at least for Scenario #3B.**

If on-demand SSB transmissions is turned on in an SCell, it may be measured by all UEs that share the same SCell. However, it is unlikely that NW would activate the SCell for all UEs at the same time. If SSB periodicity adaptation is signaled via MAC CE, which is a UE specific signaling, it follows that not all UEs may be aware of on-demand SSB periodicity change. However, this may not be required, as we exemplify in the following.

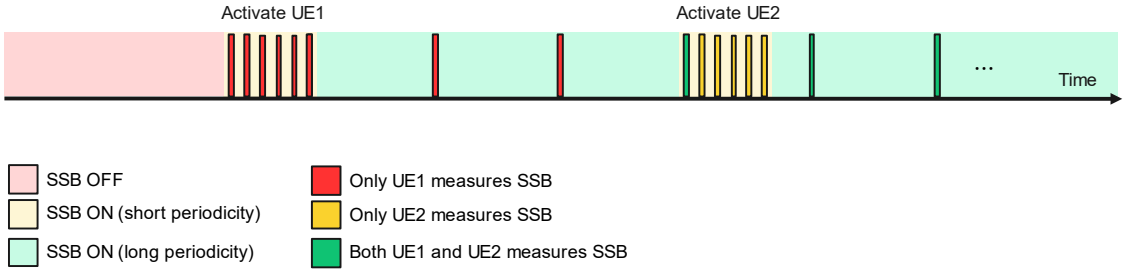

Figure 2 **Example of on-demand SSB periodicity adaption with two UEs in the SCell.**

Consider Figure 2 where two UEs, UE1 and UE2, are configured in the same SCell. With on-demand SSB for Case #1 (i.e., when there is no always-on SSB present in the cell) SSB can be turned OFF and, thus, gNB can go to sleep as long as both UEs are deactivated. When SSB is turned ON, gNB may send it with different periodicity, e.g., as follows:

1. When UE1's SCell is to be activated, SSB is provided with short periodicity (e.g., 20 ms).
    - UE1 receives indication that SSB is ON with short periodicity and measures SSB with short periodicity for SCell activation.
    - UE2 does not receive indication that SSB is ON and, therefore, is not aware of and does not measure SSB.
2. When UE1's SCell activation is completed, SSB is provided with long periodicity (e.g., 160 ms).
    - UE1 receives indication that SSB is ON with long periodicity and measures SSB with long periodicity for RRM.
    - UE2 does not receive indication that SSB is ON and, therefore, is still unaware of, and does not measure SSB.
3. When UE2's SCell is to be activated, SSB is provided with short periodicity (e.g., 20 ms).
    - UE1 does not receive indication that SSB is ON with short periodicity and, hence, continues to measure SSB with long periodicity for RRM.
    - UE2 receives indication that SSB in ON with short periodicity and measures SSB with short periodicity for SCell activation.
4. When UE2's SCell activation is completed, SSB is provided with long periodicity (e.g., 160 ms).

- UE1 has already received indication that SSB is ON with long periodicity and, hence, continues to measure SSB with long periodicity for RRM.
- UE2 receives indication that SSB is ON with long periodicity and measures SSB with long periodicity for RRM.

In this way, MAC CE based periodicity adaptation can be supported for the case when multiple UEs share the same serving cell. Each MAC CE indication is for the monitoring behavior of a specific UE, what that specific UE can expect. The gNB transmission of on-demand SSBs may go beyond that.

Observation 3 **Each on-demand SSB MAC CE indication is for the monitoring behavior of a specific UE, what that specific UE can expect. The actual gNB transmission of on-demand SSBs may be more often than what is indicated to that UE.**

2.2.2 Adaptation of on-demand SSB positions in burst

So far, only MAC CE indication of on-demand SSB periodicity has been agreed, and other parameters are FFS according to the above agreement. In our view, there are benefits with supporting dynamic indication of SSB positions in burst. Indeed, since on-demand SSB not on the sync raster is not providing idle-mode coverage, NW can save energy by sending SSB only in the direction(s) of the configured UE(s). This has the additional advantage that UE has to measure on fewer SSB beams, which reduces UE complexity.

Observation 4 **NW can save energy by transmitting on-demand SSB only in the direction(s) of the configured UE(s).**

However, said direction(s) may not be known to the NW upon SCell configuration. Hence, NW may have to adapt on-demand SSB after initial provision, which requires different SSB positions in burst configurations across different on-demand SSB configurations and that NW can dynamically indicate an SSB positions in a burst configuration to the UE.

Proposal 6 **Multiple candidate values of SSB positions in burst can be configured by RRC and the applicable value can be indicated by MAC CE for on-demand SSB transmission indication for the cell.**

For simplicity, the on-demand candidate SSB positions in a burst should be restricted to existing candidate SSB positions in a bursts.

Proposal 7 **On-demand candidate SSB positions in a burst are restricted to legacy candidate SSB positions in a burst.**

2.2.3 Adaptation of number of on-demand SSB bursts

When on-demand SSB is deactivated according to Option 2, an open question is for how many SSB bursts, *N*, the on-demand SSB will be provided. For maximized network energy savings, RAN1 should strive to minimize *N* in all scenarios. However, the minimum required number of SSB bursts may depend on the scenario. For a deactivated SCell, on-demand SSB should be provided for a sufficiently long duration to allow the UE to perform deactivated SCell measurements (note that RAN4 is currently discussing faster deactivated SCell measurement mechanisms for minimizing the duration of on-demand SSB provision). For an activated SCell, if timer-based SCell deactivation is configured, on-demand SSB need to be provided for, at least, the duration of the SCell deactivation timer. These two durations, and the corresponding values of *N*, would be typically different. Therefore, the MAC CE for on-demand SSB transmission indication could directly indicate the duration of the on-demand SSB transmission, to minimize the number of unnecessary on-demand SSB transmissions.

Proposal 8 **Multiple candidate values of number of SSB bursts (or length of timer) can be configured by RRC and the applicable value can be indicated by MAC CE for on-demand SSB transmission indication for the cell.**

To support on-demand SSB deactivation via MAC CE, i.e., Option 1, it needs to be possible to indicate via MAC CE that on-demand SSB is transmitted until explicitly being turned off.

2.3 Multiplexing of on-demand SSB and always-on SSB

2.3.1 Frequency and time offset

In [2], RAN4 sent question to RAN1 asking about relation in time domain and frequency domain between on-demand and always-on SSB for Case #2. This was discussed in RAN1#119 and the following as agreed:

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

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.

In our understanding, the following multiplexing cases, which are illustrated in Figure 3 to Figure 6 for the case when always-on SSB periodicity is four times larger than on-demand SSB periodicity, are possible and should be considered:

- Mux-Scenario 1: Same frequency and same time offset between on-demand and always-on SSB.
- Mux-Scenario 2: Same frequency and different time offset between on-demand and always-on SSB.
- Mux-Scenario 3: Different frequency and same time offset between on-demand and always-on SSB.
- Mux-Scenario 4: Different frequency and different time offset between on-demand and always-on SSB.

Observation 5 **The possible scenarios for multiplexing of on-demand SSB and always-on SSB in an SCell are Mux-Scenario 1—4.**

Note that a special case of Mux-Scenario 3 and 4 is when the different frequencies are such that on-demand and always-on SSB are partially overlapping.

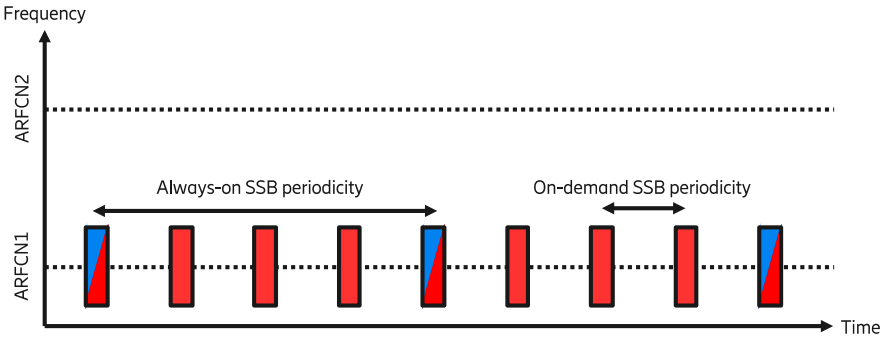

Figure 3 **Mux-Scenario 1: Same frequency and same time offset. Here, always-on SSB bursts are shown in blue and on-demand SSB bursts are shown in red.**

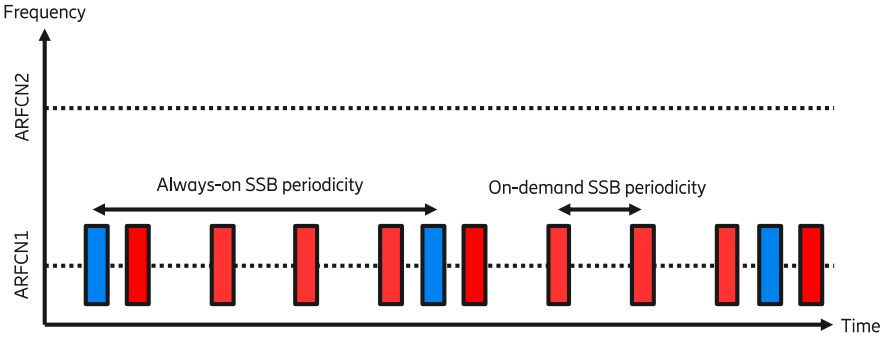

Figure 4 **Mux-Scenario 2: Same frequency and different time offset. Here, always-on SSB bursts are shown in blue and on-demand SSB bursts are shown in red.**

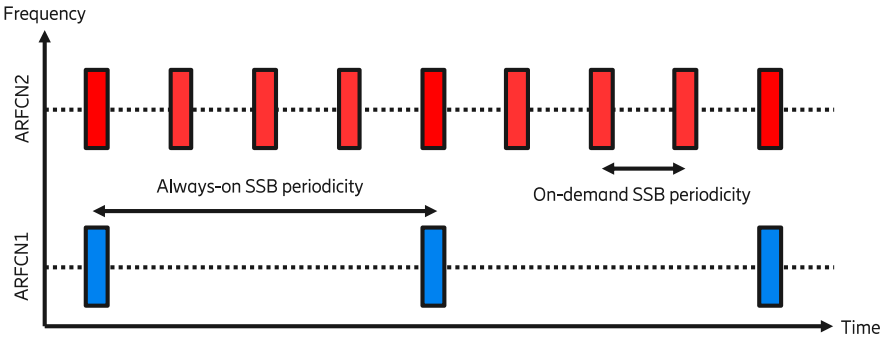

Figure 5 **Mux-Scenario 3: Different frequency and same time offset. Here, always-on SSB bursts are shown in blue and on-demand SSB bursts are shown in red.**

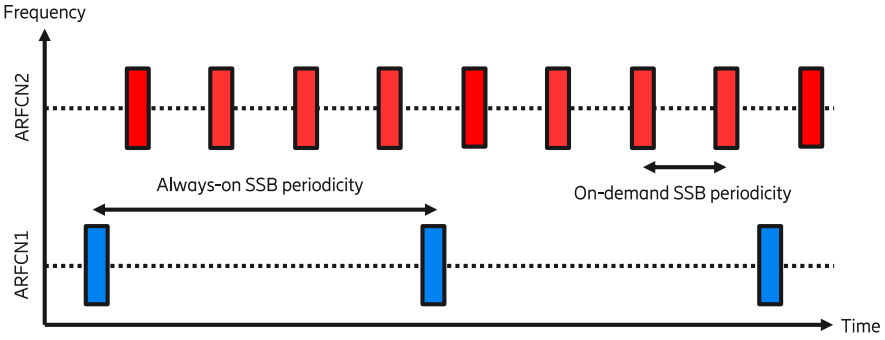

Figure 6 **Mux-Scenario 4: Different frequency and different time offset. Here, always-on SSB bursts are shown in blue and on-demand SSB bursts are shown in red.**

It has been already agreed that on-demand SSB and always-on SSB in the same SCell can be the same frequency, at least for the case when the always-on SSB is not CD-SSB. An open question is whether they can be on different frequencies.

If always-on SSB is provided on a frequency that is located on GSCN raster (ARFCN1 in Figure 5 and Figure 6), then on-demand SSB should preferably be provided on a different frequency (ARFCN2 in Figure 5 and Figure 6), which is not on the sync raster, to not confuse legacy UEs performing initial access.

Observation 6 **If always-on SSB is located on sync raster, it is preferred that on-demand SSB and always-on SSB are provided on different frequencies.**

Thus, depending on frequency of always-on SSB, it may be preferred to provide on-demand SSB on the same or on a different frequency.

Proposal 9 **On-demand SSB and always-on SSB can be provided on the same frequency or on different frequencies.**

Regarding time offset relation between on-demand and always-on SSB, in our view, at least same time offset should be supported, as this minimizes SSB footprint (compare Figure 3 and Figure 4).

Proposal 10 **On-demand SSB and always-on SSB can be provided with the same time offset.**

Based on the above discussion, of the identified multiplexing cases in Observation 5, at least Mux-Scenario 1 and Mux-Scenario 3 should be supported.

Proposal 11 **For multiplexing of on-demand SSB and always-on SSB in an SCell, support at least Mux-Scenario 1 and Mux-Scenario 3.**

2.3.2 Overlapping SSB bursts

In RAN1#119, the following was agreed;

Agreement
Response to Q4 (What is the spatial relation between the always-on SSB and OD-SSB?) of Obj.1:

- SS/PBCH blocks with the same SSB indexes for always-on SSB and on-demand SSB are quasi co-located with respect to Doppler spread, Doppler shift, average gain, average delay, delay spread, and when applicable, spatial RX parameters.
  - Applies at least for the case when the center frequency locations of always-on SSB and OD-SSB is same
- When a signal/channel is configured to be QCLed with a SSB index, the signal/channel is QCLed with the same SSB index of always-on SSB and on-demand SSB (if transmitted) with the same QCL parameters according to existing specifications
  - Applies at least for the case when the center frequency locations of always-on SSB and OD-SSB is same
- At least the case where SSB indices within on-demand SSB burst are identical to SSB indices within always-on SSB burst is supported. RAN1 is discussing whether to support the case where SSB indices within on-demand SSB burst can be subset of SSB indices within always-on SSB burst.

If on-demand SSB and always-on SSB are provided on the same frequency and with the same time offset, but with different periodicity, always-on SSB and on-demand SSB will overlap in every always-on SSB burst as depicted in Figure 3. In the below, we discuss how to handle such collisions.

We start by noting that legacy UEs, which do not support on-demand SSB, would be configured only with always-on SSB, and would expect always-on SSB bursts to be provided without interruptions. Hence, at least the SSBs in the always-on SSB burst must be transmitted in overlapping SSB bursts.

Observation 7 **If an always-on SSB burst collides with an on-demand SSB burst, all SSBs in the always-on SSB burst must be transmitted to not confuse legacy UEs.**

As discussed in the above, one reason for providing on-demand and always-on SSB on the same frequency is that Rel-19 UEs can utilize both for L1/L3 measurements. To enable combining of on-demand SSB and always-on SSB, they need to be the same in overlapping SSB positions in a burst.

Proposal 12 **If an SSB in an on-demand SSB burst fully overlap in frequency and time with an SSB in an always-on SSB burst, then the SSB in the on-demand SSB burst is identical to the corresponding SSB in the always-on SSB burst.**

Here, identical means that SSB contents (PSS, SSS, PBCH, DMRS) is the same across on-demand SSB and always-on SSB (note that this implies that PCI is the same for on-demand and always-on SSB). Furthermore, to not confuse legacy UEs, they should be provided with the same beam (spatial relations with other signals/channels should be maintained over on-demand an always-on SSB).

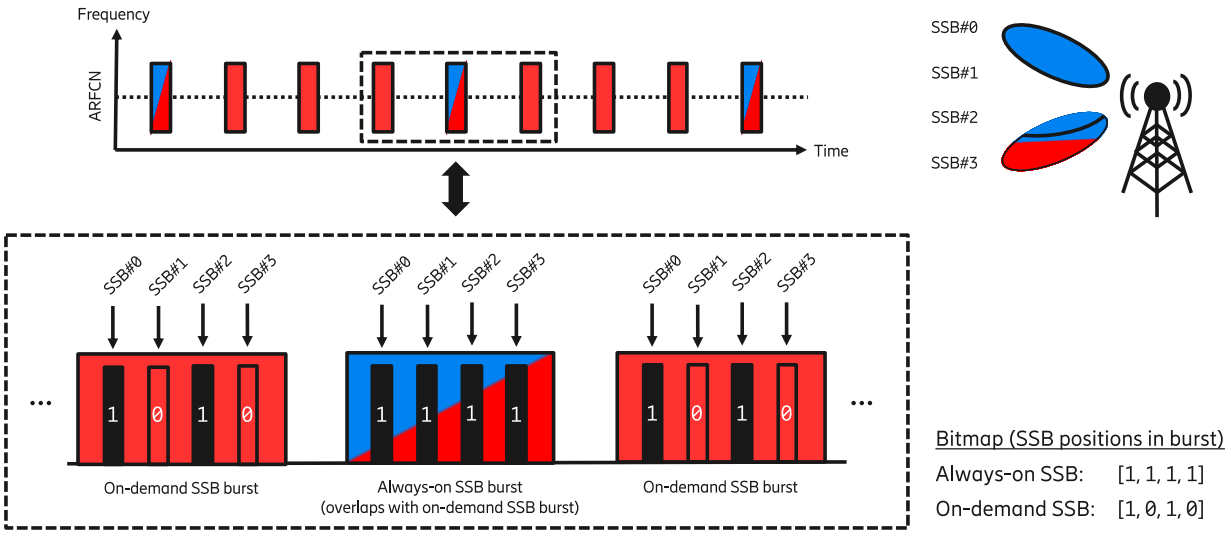

Figure 7 **Example of overlap between on-demand SSB and always-on SSB for the case when SSB positions in a burst varies over on-demand SSB and always-on SSB.**

An interesting case is when on-demand and always-on SSB can be configured with the same frequency and time offset, but with different SSB positions in burst, as exemplified in Figure 7. Such configurations are of interest, e.g., for the case of NW temporarily providing on-demand SSB with short periodicity to a Rel-19 UE for which it knows already which SSB beam(s) are suitable for, e.g., SCell activation, while still transmitting always-on SSB with long periodicity to legacy UEs on the same carrier. In this case, a UE configured with only always-on SSB would measure on SSB index 0—3 in only the always-on SSB bursts. A UE configured with on-demand SSB would measure on at least SSB index 0 and 2 in the on-demand SSB bursts, that are identical to SSB index 0 and 2 in the always-on SSB in the case of collision.

Proposal 13 **On-demand SSB positions in burst can be the same or a subset of always-on SSB positions in burst.**

So far, we have discussed collisions only for the case when an SSB in an on-demand SSB bursts are fully overlapping in time and frequency with an SSB in an always-on SSB burst. There are, however, other overlapping cases: fully overlapping in time but not overlapping or partially overlapping in frequency.

Proposal 14 **Further discuss collision between on-demand SSB and always-on SSB that are fully overlapping in time but not overlapping or partially overlapping in frequency.**

Note that partial overlap in time between on-demand and always-on SSB is not possible if legacy SSB patterns, i.e., those in TR 38.213, are reused, which is preferred.

Proposal 15 **On-demand SSB burst patterns are restricted to legacy SSB burst patterns.**

2.4 L1 measurements

In RAN1#118bis, the following was agreed:

Agreement
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 existing specification, for the case when multiple SSBs are configured in the same serving cell, e.g., when non-cell-defining SSB configured via *NonCellDefiningSSB* (for RedCap devices) is provided, the CSI report configuration is not explicitly associated with one of cell-defining or non-cell-defining SSB. Indeed, SSBs used for CSI reporting is configured via the *CSI-SSB-ResourceSet* IE, which configures a set of SSB indices (via the *SSB-Index* IE).

Note that non-cell-defining SSB can be configured only in a RedCap-specific initial BWP that does not contain cell-defining SSB or a dedicated BWP that does not contain the cell-defining SSB. Hence, cell-defining SSB and non-cell-defining SSB cannot be provided on the same frequency, which is in contrast to always-on SSB and on-demand SSB, as per above agreement.

Since a CSI report is associated with an *SSB-Index*, if both always-on SSB and on-demand SSB is configured for a UE, a CSI report can be associated with one or both of always-on SSB and on-demand SSB depending on whether SSB index in the CSI report (configured via *SSB-Index* IE in *CSI-SSB-ResourceSet* IE) is transmitted in one or both of always-on SSB and on-demand SSB and depending on whether both on-demand and always-on SSB is provided to the UE in the same BWP or not.

Proposal 16 **A CSI report configuration can be associated with one or both of always-on SSB and on-demand SSB depending on NW configuration.**

2.5 Time location of on-demand SSB transmission

In RAN1#118bis, the following was agreed:

Agreement
For a cell supporting on-demand SSB SCell operation, support to configure time domain location of on-demand SSB per on-demand SSB periodicity by RRC for both Case #1 and Case #2.

- For Case #1 (i.e., No always-on SSB on the cell),
  - Based on two parameters, where one is to indicate SFN offset from a reference point and the other is to indicate half frame index
    - The reference point is SFN which satisfies (SFN index *10) modulo (OD-SSB periodicity) = 0
    - If SFN offset parameter is NOT configured, UE assumes SFN offset set to 0.
    - If half frame index parameter is NOT configured, UE assumes half frame index set to 0.
    - The value range of SFN offset is 0 to 15 unless longer periodicity for on-demand SSB than 160 ms is introduced.
    - The value range of half frame index is 0 or 1.
- For Case #2 (i.e., Always-on SSB is periodically transmitted on the cell), down-select one of the following alternatives.
  - Alt A: Same as for Case #1
  - Alt B: Based on a single parameter which is to indicate the time offset between always-on SSB and on-demand SSB (e.g., similar to ssb-TimeOffset).

It is preferred that configuration of on-demand SSB does not depend on whether another parameter has been configured or not. For simplicity, the same parameters should configure on-demand SSB for all cases.

Proposal 17 **For Case #2 , support Alt A (same as for Case #1).**

Previous agreements on timing of on-demand SSB is restricted to on-demand SSB transmissions indicated by MAC CE signaling. However, it has been agreed that on-demand SSB transmissions can also be indicated by RRC configuration (e.g., direct SCell activation). In our view, if on-demand SSB is turned ON by RRC configuration, then it is no different from always-on SSB until it is turned OFF, and, hence, UE can determine timing of on-demand SSB according to legacy behavior for always-on SSB.

Proposal 18 **Timing of on-demand SSB transmissions that are turned ON by RRC configuration follows legacy behavior for always-on SSB configured by RRC.**

2.6 On-demand SSB being cell-defining or not

In RAN1#119, the following was agreed:

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.

The following proposal summarizes our view on the above alternatives (see also discussion in Section 2.3).

Proposal 19 **Support at least 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) and 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).**

As long as on-demand SSB is not located on the sync raster, it would not be detectable by legacy UEs. Hence, there is no reason for restricting on-demand SSB to only be not cell-defining SSB.

Proposal 20 **Support on-demand SSB that is cell defining or not cell defining, and that is not located on the sync raster.**

Conclusion

In the previous sections we made the following observations:

Observation 1 **The functionality of Option 4 can be realized by Option 1 if a MAC CE that deactivates the on-demand SSB can also deactivate the SCell.**

Observation 2 **The functionality of Option 4A can be realized by Option 2 if the on-demand-SSB transmission is restarted when the SCell deactivation timer is restarted.**

Observation 3 **Each on-demand SSB MAC CE indication is for the monitoring behavior of a specific UE, what that specific UE can expect. The actual gNB transmission of on-demand SSBs may be more often than what is indicated to that UE.**

Observation 4 **NW can save energy by transmitting on-demand SSB only in the direction(s) of the configured UE(s).**

Observation 5 **The possible scenarios for multiplexing of on-demand SSB and always-on SSB in an SCell are Mux-Scenario 1—4.**

Observation 6 **If always-on SSB is located on sync raster, it is preferred that on-demand SSB and always-on SSB are provided on different frequencies.**

Observation 7 **If an always-on SSB burst collides with an on-demand SSB burst, all SSBs in the always-on SSB burst must be transmitted to not confuse legacy UEs.**

Based on the discussion in the previous sections we propose the following:

Proposal 1 **Support Option 1 for both deactivated and activated SCells.**

Proposal 2	**Support restarting or prolonging an on-demand SSB transmission at the same time as the SCell deactivation timer is restarted.**
Proposal 3	**Support NW providing on-demand SSB transmission indication (i.e., that SSB is turned ON or OFF) and on-demand SSB configuration indication (e.g., SSB periodicity) at the same time.**
Proposal 4	**An on-demand SSB transmission indication for an SCell (e.g., ON/OFF or parameter change) overrides a potentially ongoing on-demand SSB transmission configuration for that SCell.**
Proposal 5	**Support adaptation of on-demand SSB periodicity via MAC CE while SCell is in an activated state, at least for Scenario #3B.**
Proposal 6	**Multiple candidate values of SSB positions in burst can be configured by RRC and the applicable value can be indicated by MAC CE for on-demand SSB transmission indication for the cell.**
Proposal 7	**On-demand candidate SSB positions in a burst are restricted to legacy candidate SSB positions in a burst.**
Proposal 8	**Multiple candidate values of number of SSB bursts (or length of timer) can be configured by RRC and the applicable value can be indicated by MAC CE for on-demand SSB transmission indication for the cell.**
Proposal 9	**On-demand SSB and always-on SSB can be provided on the same frequency or on different frequencies.**
Proposal 10	**On-demand SSB and always-on SSB can be provided with the same time offset.**
Proposal 11	**For multiplexing of on-demand SSB and always-on SSB in an SCell, support at least Mux-Scenario 1 and Mux-Scenario 3.**
Proposal 12	**If an SSB in an on-demand SSB burst fully overlap in frequency and time with an SSB in an always-on SSB burst, then the SSB in the on-demand SSB burst is identical to the corresponding SSB in the always-on SSB burst.**
Proposal 13	**On-demand SSB positions in burst can be the same or a subset of always-on SSB positions in burst.**
Proposal 14	**Further discuss collision between on-demand SSB and always-on SSB that are fully overlapping in time but not overlapping or partially overlapping in frequency.**
Proposal 15	**On-demand SSB burst patterns are restricted to legacy SSB burst patterns.**
Proposal 16	**A CSI report configuration can be associated with one or both of always-on SSB and on-demand SSB depending on NW configuration.**
Proposal 17	**For Case #2 , support Alt A (same as for Case #1).**
Proposal 18	**Timing of on-demand SSB transmissions that are turned ON by RRC configuration follows legacy behavior for always-on SSB configured by RRC.**
Proposal 19	**Support at least 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) and 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).**
Proposal 20	**Support on-demand SSB that is cell defining or not cell defining, and that is not located on the sync raster.**

References

[1] RP-242354, “Enhancements of network energy savings for NR”, 3GPP TSG RAN Meeting #105, Melbourne, Australia, September 9—12, 2024.

[2] R1-2409350 (R4-2416913), “LS on SSB relation in On-demand SSB and SSB adaptation on SCell”, RAN1#119, Orlando, FL, November 18—22, 2024.